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THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

FEBRUARY 1, 1960 Vol. 50, No. 5

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REVISED INDIRECT COST POLICY FOR NSF RESEARCH GRANTS

In connection with its programs for the support of basic research, the National Science Foundation for some years has followed the policy of permitting institutions to apply for and receive, as an indirect cost allowance, up to 15% of the total direct costs involved in approved grant proposals.

Because of rising costs of adminisitration and the adverse effect of such increases upon the ability of institutions to carry on research work, the Foundation has made a revision in its indirect cost policy.

Pending completion of a study of the entire problem of indirect costs, the Foundation announces that, effective January 1, 1960, it will permit institutions to request up to 20% of total direct costs as the allowance for indirect costs in research proposals. In no event, however, may such indirect costs exceed the last "audited" or "negotiated" rate approved for the institution by a Federal agency for purposes of Government-sponsored research and development.

Thus, an institution with an "audited" or "negotiated" indirect cost rate so approved may claim such rate provided it does not exceed 20% of the total direct costs.

This announcement will be reflected in the forthcoming revision to the 1955 edition of the National Science Foundation brochure on "Grants for Scientific Research."

Do You Know . . . .

► . . . . That February 1 marked the fifth anniversary of the location of ASEE's headquarters at the University of Illinois? It was originally intended that this entire DYK be devoted to what has happened to ASEE during those five years, but there never was time to write things down—too many interesting things are going on all the time. Suffice it to say that five years ago the Secretary thought running a little office on half-time and concentrating on the teaching of the behavior of materials on the other would be ideal—only two things to think about! But what a change there has been! And there will be more in the next five years. ASEE is at a real crossroads. Should it be dynamic, expand to accept its challenges and contribute to the developments the future indicates to be necessary, or should it sit on its haunches and passively watch what develops? You, the members, ultimately will decide—by your enthusiasm, your energy, your ideas, and perhaps also by your pocketbooks.

► . . . . That to bring the Yearbook up to date 2,976 changes were made in the alphabetical listing, 2,014 in the geographic and 1,569 in the occupational? Included in these "changes" are the data for the 963 new members. These numbers are considerably less than those for last year. Perhaps teaching staffs are becoming stabilized; or perhaps the records are better.

► . . . . That the first ASEE Workshop for Engineering Teachers sponsored by the Pacific Southwest Section was held at Cal Tech on November 7th? The topic was "The Digital Computer and Its Applications to Problems in Civil, Electrical and Mechanical Engineering." Eighteen participants and fifteen observers from eleven colleges attended the one-day session. This is a highly desirable type of Section activity and the Pacific Southwest Section and Cal Tech are to be congratulated.

► . . . . That an International Conference on Electrical Engineering Education will be held at Syracuse University in July of 1960? Through the efforts of the Electrical Engineering Division, ASEE will serve as a joint sponsor with Syracuse University. ASEE's representative on the Planning Committee is J. H. Mulligan, Jr., and additional information can be obtained either from him or from Stanford Goldman of the Department of Electrical Engineering at Syracuse University.

► . . . . That 46 conferees gathered in Cleveland, November 19–21, to discuss the major problems of instructor development uncovered during CDEF's year of studying such activities in engineering? Psychology, sociology, history, and education were represented, as well as chemistry, physics, and various branches of engineering. The "open meeting" referred to in last month's DYK will constitute ECAC's general session at the Annual Meeting at Purdue, June 20–24, 1960. Look forward to CDEF's final report in the May issue of the JOURNAL. The June program will be CDEF's swan song, but other groups will be established to carry on identified and worthy activities.

► . . . . That as part of its teacher-development program CDEF wants to know what the beginning engineering teacher wants to know that isn't in "You and Your Students"? Send comments and suggestions to H. A. Foecke, Assistant Professor of Electrical Engineering, P. O. Box 89, University of Notre Dame. Y^2S is one of the little manuals which deans of engineering should have on hand for distribution to all young teachers, and of which over 8,000 copies have been sold by ASEE in bulk shipments. Single copies can be obtained without charge from MIT, Director of Admissions, Cambridge 39, Mass.

► . . . . That the Ford Foundation believes the most serious need of engineering education at the present is the

forthright preparation of more and better educated men for its faculties? Because this need is crucial over the next few years heavy responsibility falls to those schools that are presently best able to aid in this effort through their doctorate and research programs. See the January issue for information on specific opportunities. On matters of concern in engineering education, deans and faculty members should take the initiative and communicate directly with the Ford Foundation.

► . . . . That the Executive Board of the Society has approved the development of a program for bringing foreign engineering educators to this country to give a series of lectures at appropriately selected colleges of engineering? The general plan is to have the men here for periods of four to eight weeks and possibly including the Annual Meeting of the Society. The Committee making the arrangements for the program will appreciate suggestions of people who should be invited to participate. The complete name, address, area of professional knowledge, and ability to speak English should be sent to the Secretary of the Society. This program will not conflict with EJC's program for the current year.

► . . . . That the National Science Foundation has approved eighteen projects under their program, "Development of New Science Teaching Aids." Two projects are listed as for use in colleges of engineering, an inexpensive supersonic wind tunnel and transparent overlay aids to use with an overhead projector to illustrate concepts in engineering graphics. Perhaps a third is a kit-style digital computer for high school and college mathematics courses. The grants average about $10,000 per project.

► . . . . That a study of machines to program large scientific meetings also is supported by NSF? Data processing techniques will be used for the meeting of the Federation of American Societies for Experimental Biology in Washington, D. C., for the scheduling of the presentation of its papers. Last year 2,383 ten-minute papers were scheduled for 235 separate sessions during a five-day period. The traditional system of scheduling also will be used and the two programs developed will be compared and evaluated.

► . . . . That NSF has granted Cooper Union $43,410 for the support of a study of the scope and content of the undergraduate curriculum in civil engineering? ASEE and ASCE are co-sponsors. Through a series of three conferences specific recommendations for undergraduate curricula designed to meet current and future needs in civil engineering are to be developed. The first two conferences will involve about thirty selected individuals and the third about 150 engineering educators from all parts of the country. At the third meeting, the concepts and conclusions reached at the first two conferences will be presented. Detailed information can be obtained from Dr. F. A. Wallace, Assistant Dean, School of Engineering, Cooper Union for the Advancement of Sciences and Art.

► . . . . That the number of master's degrees awarded in engineering in the United States in 1958–59 increased 7% over the preceding year? This compares with an 11% increase for 1957–58. The 714 doctor's degrees granted are 10% more than the number for 1957–58. Complete enrollment and degree data for institutions having ECPD-accredited curricula will be in the Yearbook-Directory that you will be receiving in two or three weeks. For 1958–59 one M.S. was granted for each five B.S. degrees and one Doctorate for each 9.4 M.S. degrees.

► . . . . That the difference between speaking and thinking rates presents an interesting learning problem? A common rate of speaking is somewhere between 120 and 160 words per minute, according to H. W. Hildebrandt of the University of Michigan, whereas we usually think somewhere between 300 to 800 words per minute. As teachers, what do we do to make effective use of this difference? Do we keep the student interested and thinking about the subject

being taught so he can weigh, deliberate, correlate, and review pertinent factors? Or do we provide him with a sufficient number of distractions and uninterestingly delivered statements so that "between thoughts" wander all over the landscape? Perhaps there is a lot of unknown science back of the art of holding the attention of a class!

► . . . . That a recent survey of 101 engineering seniors indicated that 29% of those employed by government agencies maintained A or B averages compared to 46% for those going into industry and 65% for those continuing a university affiliation? The data come from an article in *Machine Design*, July 9, 1959, by J. L. Seminara.

► . . . . That a revised "Personal Appraisal" questionnaire is available from ECPD? It is designed for use by the young engineer who wishes to make a serious analysis of himself and his job and then plot a course to meet the established needs. Single copies cost 15¢ each. Professional development is a lifetime process, and a good start during "Your First Five Years" is as important in teaching as in any other area. To guide the engineer in his ability to deal with men and affairs and to give direction to the ability to read and absorb the written experience of others, ECPD also announces a revision of "Selected Reading for Young Engineers." The suggestions are in the fields of biography, travel, history, economics and sociology, psychology, philosophy, natural sciences, and general literature. Single copies cost 15¢ each.

► . . . . That the new President of Engineers Joint Council is Augustus B. Kinzel, Vice President, Research, Union Carbide and Carbon Corporation? The new Vice President is Cecil Boling. They represent AIME and ASHRAE, respectively, on EJC's Council.

► . . . . That Dr. Harry C. Kelly now is the Associate Director (Scientific Education) of NSF and will be concerned with over-all policy aspects of Foundation support of scientific education and relationships with other agencies with responsibilities in this field? As of January 1, 1960, Dr. Richard H. Bolt becomes the Associate Director (Research); he succeeds Dr. Robert R. Brode, who has returned to the University of California. Dr. Bolt is a physicist and has been with MIT since 1946. Dr. Kelly's successor as Assistant Director for Scientific Personnel and Education is Dr. Bowen C. Dees. Dr. Dees also is a phyiscist, has been with the Foundation since 1951, and has been a member of ASEE since 1955.

► . . . . That four programs in engineering have been approved by the "Course Content Improvement Section" of NSF's "Division of Scientific Personnel and Education"? They are on materials in electrical engineering, at Case, new senior laboratory program in aeronautical engineering emphasizing research-type experimentation, at Purdue, study of undergraduate curricula by Cooper Union (ASEE and ASCE are joint sponsors), and AIChE's study of curricula implications of changes resulting from research and development in their field.

► . . . . That a five-week field study and seminar devoted to "The Big Reforms in Soviet Education" of 1959–60 is being planned for American educators by "The Trade Union of Educational and Scientific Workers of the USSR"? This is the second such program. Participants will gather in New York on about August 14 and the cost will be about $1,700. Inquiries should be sent to Dr. G. H. Read, Comparative Education Society, Kent State University. The Commission on International Education of Phi Delta Kappa is co-sponsoring the program.

► . . . . That "Machines and Tooling" is a cover to cover translation of Russia's monthly production journal? It is published by the Production Engineering Research Association, Melton Mowbray, Leicestershire, England. Subscriptions in the U.S.A. and Canada cost $12.00 per year, but for libraries of educational institutions in those countries there is the special rate of $9.00.

(*Continued on page 436*)

Nominees for ASEE Offices, 1960-1961

Following are brief biographical sketches of those who had been duly nominated, for the respective offices indicated, by the deadline for nominations, January 15, 1960.

For President, One Year Term

Eric A. Walker, President of The Pennsylvania State University, has been a member of ASEE since 1938. He served as a member of the General Council, 1950–52, as Vice President, 1952–54, and as Chairman of the ECRC Advisory Committee on Research Capabilities and Potentialities. He was also a member of the Committee on Evaluation of Engineering Education.

He received his B.S. from Harvard in 1932, his M.S. there in 1933, and the Sc.D. in 1935. He taught electrical engineering and served as head of department at Tufts University and the University of Connecticut. He was Associate Director of the Harvard Underwater Sound Laboratory 1943–45, and then moved to The Pennsylvania State University as head of Electrical Engineering and Director of the Ordnance Research Laboratory. He was on leave to the National Research Council 1949–50 and to the Department of Defense 1950–51. He was Dean of Engineering at Penn State 1951–56, Vice President of the University briefly in 1956, and then became President.

For Vice President, General and Regional Activities West of the Mississippi River, Two Year Term

Melvin R. Lohmann, Dean of Engineering at Oklahoma State University, has been a member of ASEE since 1946. He served as a member of the General Council 1954–56.

Dean Lohmann received his B.S. from the University of Minnesota in 1937, his M.S. from the University of Pittsburgh in 1941, and his Ph.D. from the University of Iowa in 1954. He has served as an assistant city engineer and as an industrial engineer in industry, as well as consultant to two oil companies and to the Board of Governors of the Federal Reserve System. He was an instructor at Pennsylvania State College in 1940–41 and became Professor of Industrial Engineering and Dean of Engineering at Oklahoma State in 1941.

For Vice President, Instructional Division and Committee Activities, Two Year Term

Newman A. Hall, Professor and Chairman of Mechanical Engineering at Yale University, has been a member of ASEE since 1948. He has served as Chairman of the Graduate Studies Division, the Mechanical Engineering Division, and the Graduate Study Commission.

Professor Hall received his A.B. from Marietta College in 1934 and his Ph.D. from the California Institute of Technology in 1938. He was a teaching fellow at Cal Tech 1934–38, an instructor in mathematics at Queens College 1938–41, research mathematician for the Chance Vought Division of United Aircraft 1941–42, engineering personnel supervisor 1942–43, power plant research engineer 1943–44, head, Thermodynamics Group, Research Department, 1944–46, head, Analysis Section, Research Department, 1946–47. He went to the University of Minnesota in 1947 as Professor of Mechanical Engineering and became Professor of Mechanical Engineering and Assistant Dean in charge of the Graduate Division at New York University's College of Engineering in 1955. In 1958 Professor Hall moved to his present position at Yale.

For Treasurer, One Year Term

W. W. Burton, Employment Manager for Minnesota Mining and Manufacturing Company, has been a member of ASEE since 1947. He was chairman of the Ethics Committee 1957–59 and is past national chairman and a director of the Relations With Industry Division. His committee memberships include the Training Committee and Ethics Committee of ECPD. He is one of the founders of the Midwest College Placement Association. He is a member of the Board of Trustees of Breck School in Minneapolis.

Burton attended the University of Minnesota from 1930 to 1934, majoring in mathematics and business, and has been staff lecturer in its Institute of Technology for several years.

The Architect and Architectural Engineer in the Nuclear Age

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I. Introduction

We are living in a day of rapidly changing ages—one day it is the Nuclear Age, the next day the Missile Age, and the next day the Space Age. Comments in this paper will be directed principally toward the period which includes the past fifteen years and the years of our immediate future—those years since the advent of the atomic bomb.

We have witnessed the use of many new developments in architecture, in architectural engineering, and building engineering during the past fifteen years—better systems of construction, new and better materials, and the use of electronic computers in analysis and design. There no doubt will be many new developments placed in common use during the next twenty year period—new materials, truly integrated building systems, use of electroluminescent panels, use of operations analysis for building planning, designing, and construction, and more general use of data processing machines to simplify the communication problems common to the architect, engineer and constructor because of the complex and diverse nature of planning, design, and construction of buildings. Each of these items deserves discussion here and it is hoped that they might be discussed later; however, this paper is limited to the presentation of certain architectural and engineering matters that are unique as a consequence of the development and use of the atomic bomb.

In this respect, what words are becoming a part of the vocabulary of the architect and architectural engineer today and tomorrow which were foreign to architects and engineers fifteen years ago?—words such as blast wave, overpressure, dynamic pressure, initial gamma and neutron radiation, shielding, and residual radiation. Matters concerning blast and nuclear radiation are of concern not only to physicists, military planners, or civil defense planners, but are important to all of us here—more important, they are of concern to leaders and teachers of our architectural and engineering professions—to the professionals planning and designing cities and buildings to be realized during the next fifteen or twenty year period. This paper does not include a discussion of detailed aspects of nuclear defense planning, theory associated with dynamic loading and response of structural systems, energies of nuclear radiation, particulate filters, shielding effectiveness of building materials, or environmental design requirements. Neither does it include a discus-

Prepared for presentation on June 18, 1959, at the 67th Annual Meeting of the American Society for Engineering Education, University of Pittsburgh and Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

sion of the effects of nuclear weapons in terms of blast overpressure, initial gamma dose, neutron dose, or residual radiation. All of us are familiar with these terms in a general manner. For a detailed, unclassified presentation, inexpensive reference such as "The Effects of Nuclear Weapons," published by the Government Printing Office and available from the Superintendent of Documents provides an excellent source of both general and detailed information.

This paper does include a discussion of the manner in which the architect and architectural engineer are concerned with the problems of nuclear defense. If a nuclear attack should ever occur, three questions which could appropriately be asked are:

1. Have the architects and engineers of this nation done their best with available resources in the planning, design, and construction of conventional buildings to ensure maximum survival of our people?
2. Have the educators of architects and engineers made certain that the graduates of today were equipped with fundamentals necessary to cope with typical problems related to survival in the nuclear age—e.g. problems such as planning and design for protection against the effects of nuclear weapons?
3. How many architectural and architectural engineering curricula included, at either graduate or undergradute level, opportunities for students to become aware of the problem of nuclear defense and its relationship to the planning, design, and construction of all buildings in the future?

Considerable time could be spent answering and debating answers to each of the three questions asked above; however, instead of answering the questions, they will serve as introduction to four basic points:

First—The formulation of the nuclear defense problem today.

Second—A discussion of the manner in which a limited number of architects and engineers can be of great assistance in the planning and design of specialized nuclear defense facilities.

Third—A discussion of the manner in which all architects and engineers can be of assistance in ensuring maximum survival of the population of the United States—when planning, designing, and constructing conventional buildings.

Fourth—A discussion of a pilot educational program in nuclear defense planning and design.

II. The Nuclear Defense Problem

We all recognize the threat that the missile—launched from an enemy submarine in the waters of the Atlantic or Pacific Ocean—has placed upon the United States. Other methods of attack using nuclear warheads are not impossible in today's defense system. A nuclear attack is quite different from a World War II attack using high explosive bombs. Protection against nuclear attack may require the creation of a fourteen day artificial environment in shelter until radiation levels are sufficiently low outside the shelter for survival. The nuclear weapon, with its accompanying blast and radiation (including fallout) covers vast areas of land—cities—hundreds of miles—even states. The protection problem is one of a regional, or rather of a national nature. With adequate shelter, the population of the United States can survive a nuclear attack.

The significance of shelter for people of the United States is indicated in the following data from a report on a Study of Non-Military Defense, prepared by the Rand Corporation, Santa Monica, California: For a 150-city thermonuclear attack with no warning for the 10 biggest cities and a 3 to 6 hour warning for all other cities, without shelters there would be 160 million of United States fatalities out of 180 million population. With a system of fallout shelters, plus arrangement for tactical evacuation (after warning of the attack) the number of U. S. fatalities would be reduced from 160 million to 60 million. With a system of blast and fallout shelters, plus arrangement for rapid entry, the number of U. S. fatalities would be reduced from 160 million to 25 million. Even for an attack on 50 cities a system of fallout shelters could reduce the number of fatalities from 90

million (without a shelter system) to 30 million (with fallout shelters).

The realization of protection for the United States cannot be separated from the economic characteristics of any shelter system. What type of shelter system can the nation afford? What types of shelter systems are the "best buy"? How can architects and engineers provide maximum protection at minimum cost?

There exists no doubt that extensive underground facilities would provide maximum protection against blast and radiation if people could enter the shelter in sufficient time. To provide this type of shelter for all areas would be prohibitive because of cost; however, in certain key cities and other regions of administrative control, a number of complex civilian underground facilities will be imperative. In military defense systems there appears to be no doubt about future underground construction. Design work and construction planning of six SAGE (semi-automatic ground environment) air defense control installations to be built above ground has been halted. Instead, such installations will be built underground. Facilities to be built underground include a new Air Defense Command Combat Control Center, several ATLAS ICBM (intercontinental ballistic missile) launching facilities, all TITAN ICBM launching facilities and the solid-fueled MINUTEMAN ICBM facilities.

III. Specialized Nuclear Defense Facilities

The planning, design, and construction of such specialized facilities mentioned above require that a limited number of architects and engineers must be able to solve in detail the problems unique to nuclear defense protection. It is therefore necessary to provide an opportunity for those persons to study:

a. structural analysis and design for dynamic loads,
b. radiation shielding characteristics of construction materials,
c. optimum integration of systems.

The first two items are self-explanatory. The third item—optimum integration of systems—is a problem that is becoming more and more important in every complex building that is designed today. It is particularly important in nuclear defense facilities where all the systems are so closely interrelated and dependent that the failure of one system might mean the failure of an entire military function. In a highly protected functional situation, where both military function and human lives are being protected as a part of such function (e.g. command center), the interdependency of systems—such as emergency power systems, ventilation systems, sustenance systems, structural systems, entrance systems, and shielding systems—is so critical that the building design must be approached on a systems analysis basis. To accomplish this objective the architectural engineers must understand fundamentals of systems analysis and fundamentals necessary for the development of mathematical models and the use of electronic computers necessary for such systems problems.

IV. Convertible Nuclear Defense Shelter

A most important item to all of us is the manner in which *all* architects and engineers can be of invaluable assistance in ensuring maximum survival of the population of the United States—when planning, designing and constructing conventional buildings.

No, our buildings and cities will not be underground, neither will the buildings be windowless, ugly, scaleless monstrosities. However, nearly all buildings have a portion which is underground; nearly all buildings have a core inside the building where windows are not needed (or desired), or have room functions requiring no windows.

Every architect and engineer can provide shelter against nuclear weapons in conventional buildings if he understands shelter requirements and the use of what I have termed "the convertible shelter." By making provision for convertible shelter space in new construction, at little or no additional expense, the architect could automatically reduce the number of possible fatalities in the event of thermonuclear attack. In every building program, whether it be school, office, church,

apartment house, or factory, there are many requirements for many functional spaces, which lend themselves for use as effective shelter against nuclear attack *if adequately planned, designed, and constructed with this objective.* The spaces may be worthy of consideration because of (1) location, (2) characteristics of materials normally surrounding such functional spaces, (3) structural systems normally required, and (4) convenience to environmental service facilities—such as water, food, filtered fresh air, heat, power, etc. Thus the architect, while carefully analyzing a planning program for a building, will find many spaces suitable for use as nuclear defense shelter as well as the intended conventional function. Such spaces would normally be used for their intended function; however, in case of attack they would convert instantaneously into shelter.

To select spaces to be designed economically as convertible shelter, the architect and engineer, during the planning and preliminary design phase of buildings, must understand the fundamental requirements necessary for survival, the effectiveness of various construction material shielding systems, effectiveness of structural systems and economic and effective systems integration. The architect must understand the internal environmental problem. Because of radioactive fallout, it may be necessary to occupy shelter spaces for as many as fourteen days. In these cases the psychological and sociological problems of survival increase and interior design, light, color, acoustics, furniture and equipment, and area and volume relationships are important.

To be effective—to provide maximum shelter at minimum expense, the convertible shelter must be planned as an integral part of the building. It cannot be "hung-on" or "attached-to" the building after the preliminary design phase has been completed. For maximum shelter effectiveness, emphasis must also be given to detail in design and construction.

For example, items such as bends in ventilation ducts to reduce radiation penetration, avoidance of loose or suspended components to reduce the internal missile hazard, massiveness of wall and floor shielding effectiveness, and lateral resistance of structural systems for blast resistance—may be very important depending upon specific shelter requirements. One could list many other considerations that would have to be made in planning and designing of that portion of a building to serve as convertible shelter.

A fundamental understanding of protection requirements and a fundamental understanding of performance capabilities and integration of systems is important in the development of shelter schemes. The architect and engineer must know what is being protected (people, material) against what effects (blast, radiation) for what length of time (one hour, fourteen days). Then using good principles of planning, and with a knowledge of performance of systems, he can provide integrated, convertible shelter in practically all buildings at little or no additional expense. Can we afford not to take advantage of such a situation?

V. A Pilot Educational Program

Items discussed have included (1) the nuclear defense problem, (2) the manner in which a limited number of architects and engineers can be of assistance in the planning and design of specialized nuclear defense facilities, and (3) the manner in which all architects and engineers can be of invaluable assistance in ensuring maximum survival of the population of the United States—while planning, designing, and constructing all future buildings. There remains one important aspect of the nuclear defense situation. Where do architectural and architectural engineering students learn about nuclear defense planning, design, and construction matters?

The architect-in-training or engineer-in-training cannot learn about fundamentals for nuclear defense planning and design in the architect's office today because there is no precedent—there is no wealth of experience from which to obtain examples of good practice. The architects' and engineers' offices do not normally consider such items as (1) ef-

fects of nuclear weapons, (2) dynamic loading and response of structural systems, (3) shielding effectiveness of materials and configurations of building construction systems, and (4) integrated systems analysis and design for optimum environmental control under emergency conditions.

On June 3, 1959, the Pennsylvania State University officially approved a pilot educational program consisting of four elective courses in Architectural Engineering to be offered in the Department of Architecture at the University Park campus. One course is an upper-class undergraduate course, serving as an introduction to nuclear defense planning and design. This course can be included in student programs in architecture or architectural engineering during the fifth undergraduate year. It may be taken as a terminal course for such students; however, it will serve primarily as prerequisite for a sequence of three more rigorous courses on the graduate level. The courses will emphasize effects of nuclear weapons, shelter planning, analysis and design of shielding systems, shelter environmental requirements, and shelter systems analysis and integration. The courses will be complemented by a research program currently being developed in order to permit and encourage graduate students in architecture and architectural engineering to pursue challenging problems of our nuclear age.

VI. Conclusion

For the architectural and architectural engineering student, our universities—our colleges and schools of architecture and engineering must be leaders in education and research in nuclear defense matters. They must provide an opportunity for students to formulate architectural and engineering problems containing nuclear defense elements, to conduct research, to solve problems, and to receive criticism. They must provide an opportunity for students to learn about the architectural and engineering fundamentals which may be necessary for survival in the age in which we are living.

In conclusion, two of the three questions posed in the introduction of this paper are repeated:

1. Have the architects and engineers of this nation done the best with available resources in the planning, design, and construction of conventional buildings to ensure maximum survival of the population of the United States?
2. Have the educators of architects and architectural engineers made certain that the students of today were equipped with fundamentals necessary to cope with typical problems of the age in which we are living—the nuclear age?

INDUSTRIAL HEALTH CURRICULUM

The Institute of Industrial Health, University of Cincinnati, is offering graduate training for professional personnel other than physicians, in the field of environmental hygiene (industrial hygiene, air pollution, industrial wastes, industrial toxicology, etc.). The professional training is provided for graduates of approved schools of engineering or science.

A three-year course of instruction leading to the degree of Doctor of Science in Industrial Health devotes two years to intensive academic study, and a third to the preparation of a thesis (additional practical work may be required as indicated).

A one-year course is also offered to qualified applicants who may be candidates for the Master of Science degree.

Two Years of Experimental Work on Various Teaching Methods and Class Sizes

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Introduction

It has been conservatively estimated that there will be a doubling of college enrollments within the next fifteen years. During this period shortages in buildings, equipment and operating funds are apt to be acute, but these physical needs may be easier to overcome than the predicted shortage of good teachers.

A shortage of faculty members already exists. A recent study (2) indicated that teaching positions were unfilled in a large number of institutions. The following quotation (6) points up the existing condition.

> The shortage of good teachers of the physical sciences, engineering, and mathematics has been widely publicized. Recently the president of a large municipal university disclosed that it was possible to fill only eighteen out of twenty-two vacant positions in engineering, and only one of the eighteen appointed was a citizen of this country.

Faced with a decreasing supply of teachers and an increase in the number of students entering college, we must search for realistic ways to solve these pressing problems. Methods must be found to increase the student-faculty ratio without sacrificing student achievement.

It is the writer's opinion that within the next few years educational research must be pursued with the same vigor as scientific research. If creative contributions to teaching are recognized and rewarded in the same manner as significant contributions to research, we have nothing to fear.

We must search out the good teacher and develop methods that will bring him in contact with a larger number of students. This study, supported by funds supplied by the Fund for the Advancement of Education and by Rensselaer Polytechnic Institute, was initiated for just this purpose.

Teaching Methods

The experiment described herein was designed to study the effect of various teaching methods on student achievement. The course Statics and Strength of Materials was chosen because it provided a number of students suitable for the experiment.

Three methods of instruction were employed: small sections (A), lecture-discussion (B), and an experimental approach to be used with large classes (C). The first two formats are rather standard in institutions of higher learning and descriptions at this point would appear to serve no useful purpose. On the other hand the experimental approach used with the large classes might prove to be of interest.

During the summer months preceding the start of the experiment the writer prepared special material to be used with the experimental sections. A study aid was conceived. This provided the student with assignments for the course, a few suggestions on study habits, and a group of questions and problems to permit the student to self-check his mastery of basic principles. The completion of the work assigned in the study aid was left as an individual responsibility.

Testing material was also prepared in advance. This consisted of a series of true-false quizzes to be given every other day, plus review quizzes consisting of

TABLE 1

STAFF CONTACT HOURS

Teaching Method	Number of Students	Number of Sections	Staff Contact Hours per Week
A	400	20	80
B	400	4 Lec.–20 Disc.	48
C	400	4	16

true-false and matching type statements, plus multiple choice problems. The review quizzes were given at approximate three-week intervals at logical breaks in the subject matter.

The four-credit-hour course was arranged so that there would be two lectures and two problem sessions per week. The true-false quizzes were given for the first ten minutes at the start of each problem session. The questions were answered in class as soon as the papers had been collected. During the remainder of the class period the students answered the questions and worked the problems assigned in the study aid. Students were given a considerable amount of freedom in that they were not required to attend the lectures and if they desired they could leave the problem sessions after the questions on the true-false quizzes had been answered by the professor. All quizzes were graded by a technical clerk who kept a record of all grades and posted course averages about every three weeks. These averages were posted so that a student could check his progress at regular intervals. To assure the student an opportunity to have all of his questions answered the professor established office hours from two until five each afternoon.

Staff Requirements

The staff requirements mandated by the several teaching methods are of interest. Considering a student load of four hundred, the staff contact hours for each method of teaching are shown in Table 1.

After making generous allowances for the salaries of technical clerks and for the costs of preparing the study aid and testing material, the proposed experimental approach will result in a considerable saving in staff time and hence ultimately a saving in dollars.

If a portion of such savings could be used to increase teachers' salaries, such salaries could be made competitive with those paid by industry. This could stop the exodus, of particularly our young men, from the campus to industry.

Organization of the Experiment

Under normal circumstances the enrollment for this course is about five hundred and fifty students per year. Within the limits, imposed by staff and scheduling, it was hoped that the students could be so divided that about equal numbers would study under each of the proposed teaching methods. Because of the fact that our staff does not approve, in gen-

TABLE 2

GROUPING OF STUDENTS

Teaching Method	Fall 1956–1957			Spring 1956–1957			Fall 1957–1958			Spring 1957–1958		
	Number of Students	Number of Sections	Staff Contact Hours	Number of Students	Number of Sections	Staff Contact Hours	Number of Students	Number of Sections	Staff Contact Hours	Number of Students	Number of Sections	Staff Contact Hours
A	117	7	28	45	2	8	193	11	44	0	0	0
B	225	3 Lec. 14 Disc.	34	0	0	0	0	0	0	0	0	0
C	85	1	4	98	1	4	226	3	12	104	1	4

TABLE 3

STAFF ASSIGNMENTS

Rank	Fall 1956–1957				Spring 1956–1957		Fall 1957–1958		Spring 1957–1958	
	A	B		C	A	C	A	C	A	C
		Lec.	Disc.							
Prof.	0	0	0	1	0	1	1	1	0	1
Assoc. Prof.	1	3	3	0	0	0	1	1	0	0
Asst. Prof.	3	0	2	0	1	0	4	1	0	0
Instructor	1	0	3	0	0	0	2	0	0	0
Asst.	2	0	6	0	1	0	3	0	0	0

eral, of the lecture-discussion method of presentation, and because this method did not appear to warrant much consideration, at the completion of the first term of the experiment, it was abandoned. The actual groupings used in the experiment are indicated in Table 2.

Staff assignments for the duration of the experiment are indicated in Table 3.

An examination of the teaching assignments indicated in Table 3 points up the general weakness of the small section and lecture-discussion approaches to teaching. Both systems require relatively large staffs with the result that some students meet with very experienced teachers; others are not quite as fortunate. The impact of this wide spread in teaching experience will be noted in the statistical section of this report.

Experimental Results

Each of the groups was allowed to proceed in the usual manner, without restraint. The examination was prepared as a joint effort of instructors involved with the course; exemptions were not allowed and each instructor graded one and the same problem on all examination papers.

General statistics for four terms of the experiment are shown in Table 4. A study of Table 4 will indicate a close parallel between the results obtained in the various terms. At this stage of the experiment the implications were such

TABLE 4

GENERAL STATISTICS

Term	Fall 1956–1957			Spring 1956–1957			Fall 1957–1958			Spring 1957–1958			Cumulative		
Method	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Quality pt. average first yr.	2.35	2.33	2.54	2.25	0	2.26	2.34	0	2.42	0	0	2.32	2.33	2.33	2.40
Number of students	117	225	85	45	0	98	177	0	216	0	0	104	339	225	503
Average exam. score	76.5	66.8	79.5	58.2	0	64.2	69.5	0	68.5	0	0	77.5	70.4	66.8	71.5
Per cent D & F grades [6 wks.]	40	41	8	53.3	0	0	39.2	0	17.8	0	0	18.2	41.2	41.0	12.8
Per cent D & F grades [final]	39.3	40.4	13	37.8	0	7.2	38	0	7.4	0	0	14.4	38.3	40.4	9.8
Quality pt. average [course]	1.83	1.90	2.41	1.79	0	2.3	1.91	0	2.21	0	0	2.31	1.86	1.90	2.27

TABLE 5

SUMMARY FOR FOUR TERMS

Method	Number of Students	Qual. Pt. Ave. First Year $\bar{X}$	Average Course Grade $\bar{Y}$	Average Exam. Grade	Equa. Relating Course Grade to Qual. Pt. Ave.	Course Grade for a Qual. Pt. Average of 1	2	3	4	Standard Deviation	Correlation Coeff. r	Qual. Pt. Ave. Course
A	339	2.33	70.3	70.4	$Y=49.2+\ 9.1X$	58.3	67.4	76.5	85.6	11.8	0.49	1.86
B	225	2.33	69.3	66.8	$Y=35.2+14.6X$	49.8	64.4	79.0	93.6	11.6	0.62	1.90
C	503	2.39	76.7	71.4	$Y=59.3+\ 7.3X$	66.6	73.9	81.2	88.5	5.9	0.69	2.28
		Theoretical			$Y=54.5+10.0X$	64.5	74.5	84.5	94.5			

that the writer was encouraged to undertake a more formal statistical analysis.

Statistical Results

The related parameters, in this study, were assumed to be the grade obtained in the course and the quality point average maintained during the freshman year. The following terminology was used:

X = the quality point average maintained during the freshman year,
Y = the grade assigned in the course,
$\bar{X}$ = the average quality point average maintained during the freshman year,
$\bar{Y}$ = the average grade assigned in the course,
σ_y = the standard deviation,
r = the correlation coefficient,
N = the number of students.

A statistical analysis was made of the grades earned by the students associated with the various teaching methods, and of the grades assigned by each instructor concerned with the course.

The results of this analysis are shown in Tables 5–8. Table 5 indicates the results obtained by the various teaching methods. An examination of this table

TABLE 6

SUMMARY—GROUP A

Instructor	Number of Students	Qual. Pt. Ave. First Year $\bar{X}$	Average Course Grade $\bar{Y}$	Average Exam. Grade	Equa. Relating Course Grade to Qual. Pt. Ave.	Course Grade for a Qual. Pt. Average of 1	2	3	4	Standard Deviation	Correlation Coeff. r	Qual. Pt. Ave. Course
A	37	2.59	72.8	66.8	$Y=47.6+\ 9.7X$	57.3	67.0	76.7	86.4	6.6	0.70	1.97
B	28	2.48	70.5	74.0	$Y=47.2+\ 9.5X$	56.7	66.2	75.7	85.2	8.5	0.61	1.80
C	28	2.19	68.2	68.5	$Y=57.5+\ 4.9X$	62.4	67.3	72.2	77.1	11.2	0.29	1.68
D	39	2.33	65.3	61.8	$Y=31.8+14.4X$	46.2	60.6	75.0	89.4	12.8	0.57	1.68
E	38	2.13	70.3	63.5	$Y=56.1+\ 6.7X$	62.8	69.5	76.2	82.9	9.4	0.42	1.94
F	46	2.25	73.5	70.5	$Y=51.0+10.0X$	61.0	71.0	81.0	91.0	11.8	0.51	1.90
G	48	2.41	70.9	78.6	$Y=43.6+11.3X$	54.9	66.2	77.5	88.8	9.6	0.59	1.85
		Theoretical			$Y=54.5+10.0X$	64.5	74.5	84.5	94.5			

TABLE 7

SUMMARY—GROUP B

Instructor	Number of Students	Qual. Pt. Ave. First Year $\bar{X}$	Average Course Grade	Average Exam. Grade $\bar{Y}$	Equa. Relating Course Grade to Qual. Pt. Ave.	Course Grade for a Qual. Pt. Average of				Standard Deviation	Correlation Coeff. r	Qual. Pt. Ave. Course
						1	2	3	4			
K	28	2.38	75.0	78.0	$Y=45.1+12.6X$	57.7	70.3	82.9	95.4	8.6	0.71	2.32
L	56	2.28	68.4	54.0	$Y=36.6+14.0X$	50.6	64.6	78.6	92.6	15.8	0.48	1.80
G	40	2.25	64.8	61.0	$Y=28.6+16.0X$	44.6	60.6	76.6	92.6	7.7	0.80	1.92
F	32	2.53	68.0	65.0	$Y=29.6+15.2X$	44.8	60.0	75.2	90.4	10.6	0.65	1.91
J	40	2.22	75.5	77.0	$Y=53.5+10.0X$	63.5	73.5	83.5	93.5	6.9	0.79	2.36
		Theoretical			$Y=54.5+10.0X$	64.5	74.5	84.5	94.5			

indicates that the students who were assigned to the experimental group:

(a) received examination scores about equal to those obtained by the students who were taught in small sections,

(b) received course grades that were a better reflection of the theoretical marking scale,

(c) received a quality point average for the course which was more nearly in line with the cumulative quality point average maintained during the freshman year.

It is also of interest to note that the standard deviation and the correlation coefficient are better for the experimental sections than for the small sections.

Tables 6–8 summarize the results of a study made on the grades assigned by each instructor during the course of the experiment. In compiling Tables 6 and 7 only instructors who taught at least two sections are included.

One can agree that, ideally, instruction should be carried on in small sections. Realistically, however, this places such a demand on the staff that many small sections come under the tutelage of relatively inexperienced teachers. Tables 6 and 7 illustrate, quite graphically, the impact of good teaching on student achievement. For example, in Table 6 note the following:

(a) The average examination grade depends in no small measure on the instructor to whom the student is assigned.

TABLE 8

SUMMARY—GROUP C

Instructor	Number of Students	Qual. Pt. Ave. First Year $\bar{X}$	Average Course Grade	Average Exam. Grade $\bar{Y}$	Equa. Relating Course Grade to Qual. Pt. Ave.	Course Grade for a Qual. Pt. Average of				Standard Deviation	Correlation Coeff. r	Qual. Pt. Ave. Course
						1	2	3	4			
J	380	2.40	76.8	72.6	$Y=61.5+6.4X$	67.9	74.3	80.7	87.1	6.6	0.56	2.28
H	66	2.45	77.6	69.5	$Y=60.5+7.4X$	67.9	75.3	82.7	90.1	7.6	0.56	2.39
C	57	2.38	74.6	66.3	$Y=43.2+13.2X$	56.4	69.6	82.8	96.0	6.1	0.79	2.10
		Theoretical			$Y=54.5+10.0X$	64.5	74.5	84.5	94.5			

(b) The standard deviation and the correlation coefficient indicate a wide variance from instructor to instructor.

(c) The credit point average for the course is, in general, considerably lower than the freshman cumulative quality point average.

One would have to conclude that the mere assignment of students to small sections does not guarantee the best instructional program.

The statements (a) through (c), indicated above, can also be made with respect to the tabulated results (see Table 7) for students who studied under the lecture-discussion system.

An examination of Table 8 will indicate that the three instructors concerned with large experimental sections were able to achieve results that do not reflect the wide divergence exhibited by the other two methods of instruction.

It is not difficult to observe that the good student does well regardless of the teaching method or the teacher. The average student, on the other hand, apparently benefited by being assigned to an experimental section.

I have always believed, and this analysis tends to substantiate the fact, that there are not enough top-notch instructors available to satisfy the requirements of the small section and lecture-discussion methods of teaching. It appears that a strong case can be made for exposing students, in large groups, to the most capable, sensitive, and stimulating teachers that a school can afford.

Student Attitudes

It has been previously noted that the experimental group differed from the other groups in two respects:

(a) The classes were larger.

(b) The approach to teaching the subject was different.

How did students in the experimental group react to these different circumstances? In the early stages of the experiment, the writer, in personal conversations with students, was given the impression that a very large portion of the group favored the method. To obtain a better picture of student reaction, a questionnaire was submitted to each experimental section at the close of each of the first three terms. The form of the questionnaire and the answers, expressed in percentages, appear in the summary on page 386.

This summary was compiled from three hundred and sixty-eight separate replies. It is interesting to note that apparently the majority of the students do not have serious objections either to the large class size or to the loss of personal contact with the instructor. It is also apparent that the methods used do not place more of a demand on a student's time.

The replies indicate that most of the students found the study aid to be helpful and they believed the true-false quizzes helped them to obtain an understanding of the subject matter. On the basis of this summary one can readily draw the conclusion that student reaction to the experiment was favorable.

Faculty Attitudes

Faculty attitudes are not quite so easily assessed. During the course of the experiment the writer reported at regular intervals to the staff of the Department of Mechanics, to the combined Science Faculty, and to the Dean of the School of Science.

On the basis of the discussions resulting from such meetings, faculty reaction to the program appeared mixed. The general attitude appears to be one of interest tempered with a great deal of caution.

A few of the faculty members felt that the experiment itself supplied the student with a motivation that would be difficult to sustain.

One of the main arguments usually advanced against the use of large sections is that it would be impossible for the professor to give the necessary time for consultation with students. Throughout the course of this experiment daily records were kept of the time so spent. For a class of eighty students this averaged about ten minutes per day. By no stretch of the imagination could one consider this an onerous burden.

SUMMARY OF STUDENT ATTITUDES

(368 replies)

	Per Cent Yes	No
1. Owing to the large size of the class, did you sense a loss of personal contact with your instructor?	31	69
2. Do you consider it a handicap to be assigned to such a large class?	17	83
3. Do you think the lectures were adequate?	96	4
4. Do you think the methods used in this course could be successfully applied to courses you have previously taken in your college career?	80	20
5. What courses (previously taken) do you think could be taught successfully using these techniques?		
(a) Physics 79 (b) Calculus 15		
(c) Chemistry 47 (d) History 13		
6. Do you feel that the running record of your marks affected your study habits favorably?	83	17
7. Estimate the time you spent in preparation for each class hour.	<1 hr. 38	
	1–2 hr. 55	
	>2 hr. 7	
8. Is the time given in question (7) less than, equal to, or greater than the time spent on the other subjects you were taking this term?	<31	
	=62	
	> 7	
9. Was the study aid a real help to you as you prepared your assignments?	92	8
10. Do you think that the true-false quizzes helped you to obtain an understanding of the subject matter?	78	22

Another argument, commonly used, is that the professor would not be able to cope with the paper work and other more or less routine duties that would increase in direct proportion to the number of students. It was possible in this course, and I feel it would be feasible in many others, to place much of this work in the hands of non-professional help.

The faculty, generally, seems to feel that the loss of personal contact with the student is a serious matter. As pointed out previously, however, the students do not have this feeling.

It was further suggested that students might have spent more time on the course, thereby reducing their effort in other courses. The students, however, have indicated quite clearly that this is a false premise.

These discussions pointed up the fact that many faculty members hold views that would be difficult to validate with quantitative data.

A commonly recurring statement by the proponents of small sections is that there are certain intangibles associated with teaching small classes that can never be even closely approximated if large classes are mandated. I do not have this feeling, because as indicated previously in this report, the important parameter is the teacher and not the size of the class. If sufficient staff were available so that each small section would come under the supervision of an excellent teacher I would be willing to concede the point. Realistically, this situation does not, and cannot, exist; hence I believe the argument is fallacious.

Conclusion

Based upon the results of this experiment, and with the cooperation of the staff members in the department, we now teach all undergraduate courses in the department in large sections. This decision has resulted in important side benefits. The decreased teaching loads have made it possible to provide additional time for research activities and for the extension of graduate offerings. Staff time was made available to explore the

possibilities of using closed circuit television for laboratory instruction.

Efforts are being made to increase the quality of the instruction. We now have under construction an experimental teaching laboratory. When complete, this facility should provide the climate and the tools for a better presentation of subject matter. This, in turn, should lead to an overall improvement in quality. We also look forward to using this laboratory for training and qualifying young men for careers in teaching. The major result of these efforts has been the establishment, within our own department, of the conviction that quantity is not inconsistent with quality.

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NSF LABORATORY CONSTRUCTION GRANTS

The National Science Foundation announces that the next closing date for receipt of proposals for support of renovation and/or construction of graduate level (doctoral) research laboratories is March 1, 1960. Proposals recieved prior to that date will be reviewed during late spring and early summer. Disposition of approved proposals will be made during late summer 1960. Proposals received after the March 1, 1960 closing date will be reviewed following the next closing date which is expected to be September 1, 1960.

This program will continue to require at least 50 per cent participation by the institution with funds derived from non-Federal sources. Proposals may be submitted for modernization or construction of research laboratories, including laboratory furnishings but not including apparatus or equipment, in any field of the natural sciences. For the present, this Program is restricted to those departments which have an on-going program leading to the Ph.D. degree. Support of facilities to be used primarily for instructional purposes will not be considered. It is suggested that, depending on the discipline involved, preliminary inquiry be made to either the Division of Biological and Medical Sciences or the Division of Mathematical, Physical, and Engineering Sciences, National Science Foundation, Washington 25, D. C. Information concerning the Program and instructions for preparation of proposals may be obtained upon request.

Comments from the Soviet Union on the Report of the Engineering Education Exchange Mission

G. G. MUKHIN

Ministry of Higher Education, U.S.S.R.

with introductory comments by

NEWMAN A. HALL

Secretary of the American Delegation

The report of the ASEE Engineering Exchange Mission to the Soviet Union appeared in the May 1959 JOURNAL. *Prior to publication a copy of the galley proofs of the report was transmitted for information and comment to G. G. Mukhin, of the Ministry of Higher Education in Moscow. Mr. Mukhin had served as representative of the Ministry during the visit of the delegation and it was believed that he could be of further assistance if an opportunity was provided for him to review our report.*

We are fortunate that in due course a detailed and constructive reply was received which amplifies and interprets the report of the delegation in significant ways. Not only are suggestions made with reference to factual items, but in addition the viewpoint of a staff member of the Soviet Ministry of Higher Education in reinterpreting our observations is made available. These comments were written informally with no thought of publication. They, of course, do not represent official views of the Ministry of Higher Education. Mr. Mukhin, however, has generously given us permission to publish his remarks, which reflect, more clearly than is possible in the report of the ASEE delegation, representative opinions in educational circles in the Soviet Union.

The comments were received in the form of a personal letter addressed to the secretary of the American delegation, Newman A. Hall, and a translation has been prepared with the assistance of Dr. Alexander Korol, of the MIT Center for International Studies. This material should be read in the context of the original report since specific reference is made to certain statements therein. A few explanatory editorial footnotes have been included.

• • • • • •

My dear Mr. Hall:

I am very grateful to you for the galley proofs of the report written by the delegation of the American Society for Engineering Education.

I was pleased to familiarize myself with this report on the system of training engineers in the USSR—a report which, it seems to me, will be of great interest to those who work in American institutions of higher learning. Although engineers are trained differently in the institutes of higher learning in the United States and the USSR, nonetheless, educators will always find much to talk about when it comes to methods and forms of student education.

The trip made by your group to the USSR and the reciprocal visit of our professors to the United States permitted us to exchange information on technical training. The information on Soviet technical schools contained in your report is of definite interest also for our specialists. The factual material of the report is very familiar to us, but in the evaluation of these facts, you unintentionally compare them with the system of education which has developed in the

United States, although this was not your aim. In any case, such steps in the development of cultural exchanges between our countries, as the reciprocal visits of professors, answer our aim to live in peace and help us better to get to know one another.

There is no question that, during the short time the delegation spent in the Soviet Union, it was difficult to make a detailed study of our system of higher technical education. Therefore, it is completely understandable that your report contains inaccuracies.

As I do not know who, exactly, wrote this or that section of the report, I address myself to you, as the author, and I ask you to offer my apologies to your colleagues for not having addressed myself to them directly with my various comments. Without disputing your conclusions, although I am reluctant to agree with them, permit me to point out several inaccuracies.

The greatest accuracy is particularly important in making general conclusions, as the effect of any error in a general conclusion is very great and could give the reader a distorted impression.

I would be afraid to assert categorically that the prestige of professors is higher than the prestige of chief engineers and managers in industry. The chief engineer of a large plant or construction bureau may not possess an advanced academic degree; but by virtue of his knowledge and experience he enjoys higher authority than a professor who works in the same technical area. There are many cases in which professors and even academicians have become well-known scholars and have received titles and degrees precisely for their work in industry. After all, prestige is determined not simply by the title of Professor, but first of all by experience, erudition and talent; that is to say, what matters is the quality of the professor or chief engineer. Therefore, the categorical nature of this assertion ought to have been softened.

It is difficult for me to estimate the amount of salary paid to managers of industry, but evidently there are many cases in which it has exceeded a professor's salary, especially where an important enterprise is concerned.

Paragraph 21 (p. 842) incorrectly indicates that, for work in research and educational institutions, an academic degree is required, while for work in industry merely a diploma is sufficient.[1]

In educational institutes, teachers who do not hold extensive industrial qualifications and an academic degree usually direct laboratory work, correct homework, and so forth. In many cases, experienced chief engineers and chief constructors from industry are invited to give lectures in special fields for students of upper courses; VAK may award them the academic title of Professor or Docent.

In research institutes, as in industry, there are many engineers with and without academic degrees. Characteristically, a man who holds neither a degree nor an academic title may work at any job right up to chief engineer. Furthermore, in many cases plant engineers defend their dissertations, receive their degrees, and continue to work at the same enterprise.

Paragraph 23 (p. 842) states that the most qualified teachers carry an easy, smaller teaching load. This is true only insofar as the number of teaching hours required of a professor is smaller than that required of a docent, and that required of a docent is smaller than an assistant's. One must keep in mind the difference in the type of teaching done by the professor and the assistant. While the professor directs diploma projects, gives lectures, directs graduate students, the assistant directs laboratory work and problem sections. The fact that a professor's teaching load is 600 hours a year and that of an assistant is 840 does not mean that the professor's load is easier.

However, if a professor or docent directs a very important research project, the number of teaching hours is somewhat lowered.

Qualified teachers may carry a light,

[1] Only a diploma is awarded on completion of the undergraduate five or five and one-half year engineering curriculum. Academic degrees refer to the graduate Kandidat or Doctor awards.

"easy"—to use your word—load so that more of their time and energy may be put into research. In that case, other teachers of the chair carry a heavy teaching load. The distribution of teaching load among the teachers is done by the head of the chair. To give the most experienced teachers a light teaching load is to misuse good teachers and in the end to give poorer training to engineers.

Notes on Other Sections

The Section on "Frame of Reference"

You are most certainly correct when you write that engineers and scientists are held in high regard in the USSR. But this is not the exclusive right of engineers and scientists; no less attention is paid in this country to writers, collective farm workers, teachers, and workers of other professions, so long as these people are experts in their fields. In the Soviet Union we greatly respect work and those people who, by their skill and success, serve as models for many others.

It occurs to me that it would have been more accurate to say that engineers and scientists are included in the ranks of the intelligentsia and not of the aristocracy of Soviet society.

The "aristocracy," in the traditional sense of the word, disappeared from our country as a social group after 1917. If one talks of intelligentsia in Soviet society, then it is a new intelligentsia of engineers and scientists who come from worker and peasant families; not a hereditary intelligentsia, but one based on their personal efforts in the service of the Motherland.

Therefore in our country the intelligentsia is not a class whose interests oppose those of the workers and peasants. Rather, it has the same aim: the creation of the classless communist society.

The development of technology is proceeding today so rapidly that the modern worker must have considerable technical knowledge.

The necessity for greater knowledge brings the worker and the engineer closer together. It seems to me that in the future the situation will not arise where a man without a diploma will at best be a foreman and a man with a diploma will start at the foreman level with the opportunity of becoming a chief engineer.

An engineer may be foreman or even a group leader, for example, in the assembly of computing machines or the adjustment of automatic machine tools, and remain in that position, not only for a familiarization period of a few months, but for several years.

On the other hand, a gifted man who begins work as a common laborer will inevitably come to the conclusion that he must increase and upgrade his knowledge.

If one compares self-education with the night school system, the night school system is found more effective. For this reason, our industry has a network of various schools and courses for raising qualifications; but higher education is available in evening institutes.

In this way, there are wide opportunities for receiving a comprehensive education, including higher education, without having to leave work.

The position of foreman remains a limit to one's ambitions if one simply doesn't care to study much.

A rather large number of people work in industry who, although they do not have the engineer's diploma, are in fact engineers by their experience and the positions they fill. The development of a system for obtaining higher education without having to leave work gives them the opportunity to study and gain the knowledge needed to work on the new developments for the progress of technology.

In our country the growing desire for higher education among a significant segment of the workers in industry brought about a sharp growth in the number of students in evening and correspondence technical institutes. Despite the development of a network of such institutes and their branches in the last five years, the number of applicants for such study has become so large that the competition

for admission is not much less severe than for regular day institutes; and in the technical correspondence institutes, it is fully as stern as in the best day institutes.

In conclusion, I should like to say that the aims and duties of Soviet higher education are best formulated in the Law on Public Education which was adopted at the session of the Supreme Soviet of the Soviet Union in December, 1958.

Section on "The Administration of the Soviet Higher Education System"

At the present time, a decision has been adopted concerning changes in the administrative organization of the institutions of higher learning. Institutions of higher learning are to be administered by those union republics in whose territory they are located.

The USSR Ministry of Higher and Secondary Specialized Education will continue to give general direction to the scientific and methodological activities of the institutes.

The Section on "Administration and Faculty of Engineering Education Institutions"

You write that in important institutes of higher learning, such as the Moscow Bauman Higher Technical School, most of the decisions are made by an "inner council" whose members are deans and heads of the most important professional courses.

This "inner council" may be the academic council of a faculty composed of the dean, the heads of chairs, and perhaps the most competent docents. The faculty council operates under the chairmanship of the faculty dean and goes over roughly the same questions as does the Institute Council. In particular, every year the faculty councils discuss the quality of the graduating engineers. Kandidat dissertations are defended before this council, and the results must be confirmed by the Institute's Academic Council.[2]

[2] The term "faculty" refers to an academic group most closely paralleling a department in American institutions. The dean of a faculty then corresponds to our department chairman.

Besides, another "inner council" may be the committee set up by the Academic Council to study various problems. For example, an experts' committee of the Academic Council of the Bauman Institute does the preliminary reading of dissertations, names the official opponents, and rejects work which does not lie within the fields of specialization of the institute or, in the opinion of the committee, does not come up to its standards of excellence. In the latter case, the author of the work may not agree with the committee, and may defend his dissertation not at the Bauman Institute, but elsewhere. The Academic Council selects the experts' committee from among its own members, but does not necessarily include deans.

The scientific technical committee of the Academic Council of the Bauman Institute evaluates the quality of completed research, recommends the best work for entry into prize competitions, etc., etc.

The Academic Council may select other committees should this seem necessary. Under no circumstances can either the faculty council or any committee replace the Academic Council.

It is not correct to state that the office of dean of any given faculty is filled in turn by the oldest professors of the faculty. No such formal regulation exists. A dean may stay in office for only a year if he is unsuccessful, or for ten years if he has authority in the faculty and successfully directs the academic and scholarly activities of the chairs.

The dean of a faculty must be a creative, experienced man whose advice will be respected by professors in charge of chairs. The dean is, of course, an administrator in the accepted definition of the word, but his duties go well beyond this definition and are much broader.

The dean takes an active part in the selection of students and in the work assignment of young engineers. The major share of his attention is directed to the academic process and the academic work of his faculty; jointly with the professors in charge of the various chairs the dean controls the quality of the lectures and projects, hires qualified teachers, etc., etc. Often the dean provides the initia-

tive for the solution of an academic problem which requires the combined efforts of several chairs.

Furthermore, the deans themselves carry on teaching and academic research work.

The report incorrectly states that the institute chairs are composed of professors who hold more than one position. Such professors—if there are any at all—constitute a very small proportion of the whole.

The number of students is related to the number of teaching staff in a ratio of 10 : 1 or 12 : 1. This figure is universal; for example, the Frunze Polytechnical Institute has a ratio of 11.6 : 1. The lack of qualified staff is illustrated by the fact that the chairs are headed by docents instead of professors, and by the fact that the percentage of teachers who do not possess advanced degrees is higher than in institutes in major cities.

The Ministry of Higher Education of the USSR confirms as professors in charge of chairs only those selected by competition. The academic titles of professor or docent are awarded to those who do not hold them yet by the Higher Attestation Commission (VAK). If an institute of higher learning selects as teachers men with the title of professor or docent, no confirmation is needed from the Ministry. A teacher (assistant, docent, professor) is considered a full member of his chair after his election by competition and confirmation by the Institute director, not by the Ministry of Higher Education.

The report quotes too high a figure for the fee paid to the author of a textbook. In fact, the compensation for a single page rarely exceeds 75–100 rubles.

Furthermore, textbooks are not written every year by every professor. Therefore, the average annual income is smaller than indicated and exceeds the income of a semi-skilled worker by 5–6 times, rather than by 7–10 times as stated in the report.

This section states that examinations run 40–60 minutes. Actually, an oral examination generally runs no longer than 30 minutes; only in rare cases, when there is doubt as to the student's knowledge, does the examination exceed half an hour. It should be noted that before an oral examination the student is given one to one and a half hours for preparation.

The report is inaccurate regarding the requirements for admission to the institutes. The fullest information on admission requirements is contained in the Regulations for Admission into Higher Education Institutions 1959, of which I am sending you a copy.[3]

I want to point out a few more erroneous statements:

1. The minimal number of grade points needed for admission to an institute is determined in the following way:

For each specialty of any institute, an admissions plan is set up by the Ministry. The number of those who have successfully completed the entrance examinations is higher than the number of open slots. The admissions committee (on which the dean serves) naturally accepts the best and closes admission when all places are 100% filled, and not 130% filled, as the report states. In this way the "passing grade" is determined by a method of natural selection, rather than by the desire of the dean or of the director of the institute.

2. For admission, work record and recommendation from the place of employment are considered, but admission does not and cannot depend on nationality or origin. The Soviet constitution guarantees equal rights to all citizens of the Soviet Union; and among these rights is the right to education, regardless of nationality.

The only case in which nationality is considered in the question of admission is that of foreign students who come to institutions of higher learning in the Soviet Union to study. In accordance with the agreements on cultural cooperation between countries, such students are unquestioningly accepted; and if you decide to send Yale students to study in the USSR, these students will receive a warm welcome from any institute.

3. It is entirely fair that in admissions, preference is shown those who possess

[3] On file at the MIT Center for International Studies.

at least two years of industrial experience. By the admissions rules, up to 80% of available slots may go to such applicants, with a minimum of 20% going to secondary school graduates. It is not planned that exactly 80% of the slots are to be taken by veterans of industry. The actual number of those with industrial experience always falls below 80%; it is lower in the cities where there are many technical institutes, and higher where there are one or two institutes. For that reason their numbers are lower in Moscow than in Frunze.

A practical application of the rule that 80% of the slots are open to industrial workers came on one occasion when for one of the specialties of the Bauman Institute there were such applications for over 80% of the places. The admissions committee explained to the applicants that because of their number all could not be admitted on preference terms. So a part of the applicants decided to apply to another institute, and a part selected another specialization.

Thus the 80% "rule" reflects a trend toward accepting more students with industrial experience. These students are given special privileges.

The actual admission figures illustrate a real balance among people with and without practical experience. The leading institutes, academically speaking, have accepted as many students with practical experience as had successfully completed the entrance examinations. I should not say that these institutions accepted these people unwillingly.

4. It is difficult to agree that students may not change their field of specialization midway in their studies. I am always running up against cases of students who want to change institutes and fields of specialization. Such changes are possible during the summer vacation and only the permission of the directors involved is needed.

There are many reasons for wanting to change—most often family circumstances, more rarely dissatisfaction with a field, and other reasons. Within one institute, changing from one field to another requires the permission of the dean of the faculty.

5. The applicants to a correspondence institute must satisfy the same requirements as for a regular institute. I spoke earlier of the competition in correspondence institutes.

Section on "Curricula"

I was surprised to read that lectures in our institutions of higher learning are formal in character. I cannot understand what led you to such a conclusion.

The lectures cover the most complicated questions of a given course and encourage interest in independent work. The lecturer cannot and need not cover all the required material in his lectures; he should recommend appropriate outside reading.

In the institutions of higher learning in the USSR, lectures on many subjects are given to large groups of students; this requires thorough preparation and teaching skill on the part of the instructor.

The world has greatly changed since Plato's time, and such unconstrained dialogues as he engaged in with his pupils are now hardly acceptable as a basic technique for teaching students. I don't wish to imply that a student must question the lecturer only by note and that oral questions are inadmissible. From my experience, I consider it better for questions to be put in the middle or at the end of a lecture, or after the conclusion of a given topic. At that point I always ask the audience whether there are any questions raised by the lecture.

Furthermore, students ask many questions at colloquia, in connection with their laboratory work and at seminars; in such cases they begin to understand the material of the lectures and clear up the questions which still bother them.

So, though our lectures are not accompanied by violent arguments between the lecturer and the audience, I cannot consider them "formal."

The student's industrial practice is a planned part of an engineer's preparation. The basic aim of industrial practice experience is an attempt to teach students right at a work station. There students work on an equal basis with the personnel of the shop or department.

carry full responsibility for their work and receive the full salary for the job they are doing. When a student is not doing a regular job, but serving instead as an assistant to an engineer, he nonetheless has definite responsibility. When the student has completed the practice session, he must make a report and pass an examination before a committee made up of the factory instructor with whom he worked, and one or two teachers from the institute. In this way, the industrial practice session is not simply an excursion, and each student must acquire definite practical habits, acquaint himself with the production process, and give an account of his activities.

If a student goes to a factory with the notion that he is not responsible for anything, he usually does badly on the examination. If he does not pass his examination on industrial practice, he must repeat the practice session and forfeit his summer vacation. Such cases are rare, but they do happen.

The changes in the system of higher education which are now being carried out will improve the industrial practice: all students will work in factories or plants, and the experience will lose its contemplative character.

The text of the diploma project must be written by hand because engineers must be able to explain their thoughts in written form clearly and correctly.

In our technical institutions, language skills are not taught and these write-ups make it possible to judge the literacy and general development of a young engineer.

On the other hand, the typing of these projects would exceedingly complicate the administration of higher educational institutions, since only some of the students own their own typewriters; because the projects are defended in the course of one month, a very crowded schedule would be necessary for the typing of all projects. Add to this the fact that, since the projects are written by the students themselves, they cannot attribute spelling mistakes and other inaccuracies in the project to the typist. Projects vary from 80 to 160 pages. Naturally the handwritten projects give some opportunity to judge how independently the project was done, but the chief criterion of the independence and technical maturity is the defense of the project itself before the committee.

The Section on "Research"

In institutions of higher learning the academic research work of the teachers receives a great deal of attention. It must be noted that in academic research work there is no effort to exclude theoretical research. Theoretical work and work of an applied nature are equally acceptable. The establishment of specialized academic research laboratories at institutes provides the conditions needed for the development of academic research work in both these directions. In the choice of research topics, teachers at higher educational institutions are guided by the general work of the chair and by their own particular interests.

In institutions of higher learning, the choice of research topics is largely determined by the wish of the researcher to work in a particular area.

In most cases members of the chairs work together on various problems within an area. This area is defined by the academic interests of the professor who is the head of the chair.

The Ministry of Higher Education in the USSR, in its direction of the academic work of the institutes, assists in the organization of such academic "collectives" from among scholars from one or more chairs. Such a research group which reflects the experience of many years of a chair permits the successful completion of scientific projects.

In institutions of higher learning, there are "schools" with different approaches to certain problems. The creation of such scientific schools is encouraged in institutions of higher learning, since they increase the effectiveness of the work of the chairs and encourage the scientific development of the teachers. Scientific criticism by scholars who work in other institutions—that is, competing schools—makes it possible to do better work and to select the direction of research more wisely.

In this connection it is wrong to ascribe to the Higher Attestation Commission the role of directing the academic work in the institutions. The Higher Attestation

Commission evaluates the work of individuals and awards academic titles and degrees on the basis of that work. For example, regardless of whether a study is concerned with theoretical research on radiowave propagation or the development of mechanical operations on universal machine tools, both authors receive the degree of Doctor of Sciences if the work is good enough.

The Higher Attestation Commission does not require research in applied science from teachers in engineering institutions and work in pure science from teachers at universities. Such demands are not even made by the Ministry of Higher Education of the USSR, which directs the academic work of the institutions of higher learning.

The Higher Attestation Commission fills a more modest role: it awards academic titles and degrees on the basis of the results of academic research work. It demands work of high quality and refuses to accept work of poor quality.

In other words, the basic principle in the direction of academic research work by the Minister of Higher Education is the broadest development of theoretical as well as applied research, regardless of the type of institution of higher learning.

Finally misstatements. There are a few of them:

1. Night school students work a normal working day, not a six-hour day. The length of the working day is determined by the branch of industry and conditions of work. It may be a six-, seven-, or eight-hour day. The length of studies in the evening branches never exceeds 16 hours a week.

2. Mechanical drawing in engineering institutions is studied two years, not four as shown in the report.

3. Among the cities which have academic consultation points of the All-Union Correspondence Polytechnical Institute, you erroneously name the cities of Vladivostok and Yakotak (p. 864). As far as I know, the latter does not exist.[4]

4. The law on reorganization of the secondary school was adopted in December, 1958, at a session of the Supreme Soviet of the USSR, and not of the Supreme Soviet of the Communist Party of the Soviet Union.

5. The Gosplan is the State Planning Committee of the Council of Ministers, USSR.

I received your galley proofs after some delay as I was on an official mission. For this reason I am late with my answer. Please forgive me.

In conclusion, I would like to take the opportunity to send to you and to your colleagues my best wishes for success in your work.

Respectfully yours,

G. G. MUKHIN

[4] Informal records of the delegation indicated consultation points at Vladivostok and Yakutsk (by typographical error printed in the report as Yakotak). The official listing (p. 910) confirms both of these to be in error.

NUCLEAR REACTORS AT IOWA STATE, MISSOURI

The 10-kw, water-moderated, graphite-reflected reactor at Iowa State University is now in operation. The reactor was brought to the initial condition of a self-sustained reaction on October 19 with Glenn Murphy, Chairman of the Nuclear Engineering Administrative Committee of the University, at the controls. The reactor, which is a part of the nuclear engineering facilities of the College of Engineering of the University, will be used for instruction and research in nuclear engineering and allied fields.

The University of Missouri College of Engineering has expanded its instructional facilities in the field of nuclear engineering with the installation of a natural uranium subcritical assembly, or reactor, Dean Huber O. Croft of the College has announced. There has also been installed extensive radiation measuring equipment which is being used in connection with the subcritical assembly and the instructional work in nuclear engineering.

The Preparation of College Freshmen for Technological Studies

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Introduction

What follows is an account of an experimental study of a technique of teaching college freshmen how to learn. The experiment was conducted with students enrolled in engineering curricula; no attempt is made to predict the success it might have with liberal-arts or other students. An effort was made to select a group large enough to permit statistical evaluation of the results, yet small enough so that an identical group could be found for use as control, while simultaneously preserving in both a substantial homogeneity of professional interest. The students were therefore selected from only three closely related curricula (metallurgy, ceramic technology, and fuel technology), whose enrollment sufficed to provide two groups, each 32 strong.

In this report the technique and the results of this particular study are described. They show an average gain of 8.7% in performance in the first 6 semesters.

Since the original experiment was performed, in the fall of 1955, a total of over 180 additional students have undergone similar training. During 1956, 1957, and 1958 certain modifications of the original technique have been tried out. The broad outlines of two promising modifications, designed for use with college-wide enrollments, are also described below.

Finally, the national necessity is argued for adopting in our universities some sort of new procedure for teaching freshman students in engineering and science curricula how to learn, be it the procedure developed in this study or some other.

Selection of Students and of General Procedure

To perform a controlled study in which a group of students is given an experimental treatment while the control group is not, one must be careful not only to choose random samples, but also to ensure that the only substantial difference in treatment is the one under study. Thus if the members of the special group were denied a subject-matter course to make room for the experimental course, performance in later semesters might be as much influenced by loss of subject matter as by addition of the special treatment. Yet if the experimental course were simply to be added to an already crowded schedule, later performance might mirror the difference in load sufficiently to make the experiment worthless.

No perfect way out of this quandary can be found, but the solution adopted in this study is submitted as being a fairly good one. All freshmen in the College of Mineral Industries at The Pennsylvania State University are required to take an orientation course, Mineral Industries Lecture. It consists of a one-hour lecture once a week for 14 weeks on the nature of the mineral industries, their role in the economy, the nature of the mineral-industries curricula, their position among other fields of learning, and the whys and hows of university study in mineral-industries areas. In addition to the 14 lectures, two examinations are given, one at mid-semester, one at the end. Home reading designed to take approximately two hours per week is assigned.

It is from class meetings of this course that the students of the experimental group were excused, but they were held

responsible for the homework and the examinations. Though they were not exposed to the weekly lectures, subject matter from those lectures and from the reading assignments was used whenever possible as the vehicle for the experimental work.

The individuals of the special group were selected by placing in alphabetical order cards bearing the names of all 64 freshmen in the three curricula involved, then taking into the experimental group those students whose names appeared on every other card. The remaining students constituted the control group, and were placed with the other freshmen of the College in the regular Mineral-Industries-Lecture course.

The experimental group was taught by the author in a separate room, and the control group, with their classmates, were lectured by Professor J. J. Schanz. Although the effectiveness of teachers is a subtle matter involving many subjective factors, the difference in quality of teaching was in this case slight. If there is a difference, it is probable that Professor Schanz would be judged a better classroom performer than the author. The fact that the special group *was* special no doubt also had an influence on its performance. In 1956 the new technique became standard for all freshmen in Metallurgy. This influence was thus removed, but it also became more difficult to evaluate performance, since the advantage of a good control group was lost. Apart from these differences, another one immediately stands out: the control group was a part of a larger class, totalling some 150 students, whereas the special group consisted of only 32 people. To obtain an evaluation of the effects of differences in class size and in teachers, five more groups, subjected to similar experimental training in 1956 and 1957, were arranged in different class sizes, and an additional teacher, Professor J. B. Wagner, Jr., led two of the groups.

It will be apparent from the results, however, that differences in teachers, specialty of treatment, and class size are relatively unimportant. The major reason is that the entire course constituted only one credit out of the approximately 115 involved in the six semesters over which the comparison was made.

Bases of the Experiment

The tools of learning which make it possible for a student to perform satisfactorily in a university (and for technical or technician personnel to perform satisfactorily in their profession) may be divided into three groups: skills, attitude, and values. Skills include the ability to read, listen, and observe at a sufficient speed with analysis, integration, understanding, and retention; the ability to calculate and to write rapidly and precisely; the ability to translate rapidly from words to numbers, and vice-versa; the ability to bring to bear on a problem relevant information from the entire body of knowledge; the ability to judge the precision of data, of solution, and of answer at a chosen level of abstraction; and the ability to husband time effectively. The order of importance and the completeness of this list may be debatable, but no one would quarrel with a statement that it contains at least some of the primary skills which a student must have in some measure at the start of his university career and in a much greater measure at its completion.

In additon to skills, the student must have the correct attitude towards the learning process. Attitude includes not only the ambition towards success in learning, but also the confidence and courage that sustain it. These are kindled and nourished by success itself, and therefore to the degree that skills in learning are developed early, so does a desirable attitude develop early.

There are a few values essential to professional learning that can be taught to students at the beginning of the freshman year if they do not already have them when they arrive. For example, one can teach the consequences of the fact that it is a privilege for them to attend the university, not a right (as in high school), nor a legal requirement (as in elementary school). One can teach that academic honesty is not a card in a game between students and faculty. One can teach that the responsibility for learning is the individual student's, not the faculty's. These

are things students should know by the time they enter, but the fact is many do not, sometimes to the extent that they do not know the very meaning of the terms "privilege," "honesty," and "responsibility." When these failings are severe, the situation is almost irremediable, but perhaps not quite. Success in learning increases the willingness to compete (and thus to take advantage of the privilege), lessens the pressure (and the temptation to try dishonest means), and increases the tendency towards independence from the teacher. Thus an improvement in learning skills can also result in helping to fill gaps in the student's armamentarium of civilized values.

It follows that the development of learning skills must be the primary aim of any course whose purpose it is to convert the product of the high school into an effective university student.

Unfortunately, two great difficulties immediately appear. First, the student who enters a technical field is highly selected. He was a good or even an excellent student in high school. It is therefore necessary to persuade him against the weight of his previous experience that he must become a much better student. He must become convinced that he is not yet skillful enough, even though he may have been the valedictorian of his high school-class, to succeed in the university without first considerably improving his ability to learn. Second, if he cannot adequately read, listen, observe, calculate, write, translate between numbers and words, integrate knowledge, judge, choose between levels of abstraction, or husband his resources, how can he be taught to do so by means of books, lectures, visual aids, problem assignments, or examinations? Teaching him how to learn cannot be done well by calling on him to use the very tools whose use he is being taught.

The Technique

To circumvent these two difficulties, a "laboratory" technique has been developed. Engineering and science students are pragmatists. A major reason for their choice of these professions is that they have in the past enjoyed building contraptions of one sort or another to see if they worked. They have liked to put figures together to get answers. They have derived satisfaction from seeing red litmus turn blue when it was supposed to. Therefore it is possible to achieve success by conducting with them an experimental investigation of the learning process. If they have themselves established by trying it that they can remember twice as much of a 30-page reading assignment by following a certain procedure, their only future departure from the better procedure will probably be to find an even better one. On this basis the technique of the course was developed: the teacher does not tell the students how to learn; he designs experiments whereby the students find out how for themselves —the problem of communication thereby disappears. The initial difficulty of persuading them that they are not skillful learners at the outset can be handled in the same experimental way.

The course is therefore a practicum, and like most such courses, it is conducted in two-hour sessions once a week, a practice which, tradition has it, is more effective than more frequent one-hour sessions.* In short, the technique of teaching to learn by experimentation rather than by lecture or demonstration makes possible the development of learning skills without making use of those same skills, and without influence from the student's preconceived opinion of his own ability.

The sequence of "experiments" is given below. For each skill studied, the experiments are designed to show the students first, their limitations in that skill; second, a way to improve their skill; and third, the fact that such a way is satisfactory. Drill in using that skill continues from then on until the end of the course. For example, every student entering an engineering or science curriculum believes he is skillful at computation. The first experiment is therefore to give him a

* Since about half the homework assigned in the Mineral Industries Lecture course is woven into the experiments, the students in the special group do not in fact have an increased study load as a result of being in class two hours a week instead of one.

series of groups of simple arithmetic problems to be done in his head (only the answers to be written down); in each group the time per problem is less than in the previous group. The scores at the beginning, for problems like

(1) $\sqrt{400} = ?$
(2) $62.8/\pi = ?$
(3) $7.281 + 2.719 = ?$
(4) $10^3 - 10^2 = ?$

each one done in 30 seconds, average around 3 correct out of 10. Typical examination questions in first-year courses are then analyzed to see what scores might be acceptable. For example, a 5-minute units-conversion problem in a freshman chemistry examination might be found to involve six arithmetic operations. To obtain a passing grade in an examination made up entirely of such problems requires, quite apart from knowledge of the chemistry involved, the ability to compute rather more than twice as efficiently as the 3-out-of-10 result indicates the students can do. The second stage of the experimental study is therefore to find a way to improve this skill. Methods are found, like seeking in problems like (3) above the pairs of figures that add up to 10, starting from the right (Thus: $9 + 1 = 10$, $8 + 1 +$ carried $1 = 10$, $2 + 7 +$ carried $1 = 10$, etc.), so that the addition becomes systematic. Other tricks are evident in the four examples shown here. One is the conversion of all numbers to powers of ten (in problem (1), $\sqrt{400} = (4 \times 10^2)^{1/2} = 4^{1/2} \times 10^{2/2} = 2 \times 10^1$; in problem (2), $62.8/\pi = 6.28 \times 10^1/\pi = 2.00 \times 10^1$). Other tricks are to arrange parts of multiple operations on the basis of common powers of 10 (in problem (4), $10^3 - 10^2 = 10 \times 10^2 - 1 \times 10^2 = 9 \times 10^2$), and rough-checking (in problem (3), the sum is nearly $7 + 3$, so the answer is near 10). After some familiarization with such methods, the third stage begins. Several series of computations have been done by this time. The instructor now gives one (or more) series that had been previously done. Scores are shown to have improved appreciably by virtue of the use of methods found during the second stage. The fourth stage consists of continuing to give groups of arithmetic problems in class almost every week until the end of the semester. The problems become more difficult, their answers are less exact (evaluations to a certain number of significant figures), and the time allowed becomes shorter. Later in the semester auxiliary studies are made. Some are: to find what kinds of computations should be done on the slide rule and what kinds are done more quickly in the head; what commonly used figures ought to be memorized (powers of 2 from $2^{1/2}$ to 2^5, π to 3 significant figures, $\log_{10} e$ to 3 figures, trigonometric functions of angles of 30°, 45°, 60°, 90°, etc.).

The second experiment, which begins the week after the first has been started (all experiments overlap), is on the subject of reading. Without going into so much detail as in the preceeding paragraph, it suffices to say here that it consists also, as they all do, of four stages. First, a reading assignment is given; the students are made to demonstrate to themselves that they cannot memorize the assignment in the time allotted. In fact, the rate of memorization is shown to be approximately one word per minute. Second, a way is found to isolate systematically ("with understanding") the words to remember, grouped into meaningful sentences of 10–15 words each (approximately 5 such sentences per hour of reading). Third, a demonstration is made that shows this systematic method makes possible much more effective learning, not only of the sentences memorized, but also of the details associated with those sentences; the understanding of the subject is also shown to be increased. Fourth, reading by this method is continued in subsequent weeks, both in class and at home.

The subjects of the remainder of the sequence of experiments are, in order:

3. Using and training the memory; relative effectiveness of auditory, visual, tactile, and combined methods of memorizing; association in remembering.

4. Taking notes while reading, for later study; quantity; nature.

5. Listening to lectures and seeing films; integration and note taking.

6. Observing experiments; what to look for; what not to look for; recording.

7. Taking examinations; judging required level of abstraction; husbanding time; writing.

8. Solving problems in which redundant data are given.

9. Solving problems in which insufficient data are given (quantitative thinking).

10. Evaluating the qualities of a professional man; character and personality; "engineering judgment."

11. Preparing, presenting, and criticizing speeches.

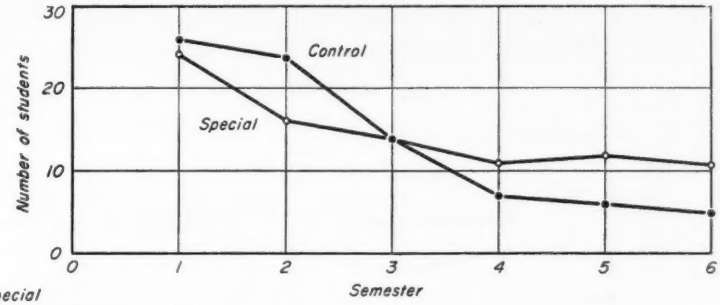
In each of these experiments the four stages are passed in sequence. There are fewer experiments than there are weeks: the last weeks are primarily devoted to the completion of the fourth stage of all experiments and to the evaluation of the interactions among the several skills. During the last weeks the students are becoming aware of their performance in their other courses, and whenever there is time the more common difficulties they encounter are studied in the light of what has been learned about the learning process.

Results of 1955 Experiment

Some of the results of the 1955 experiment are shown in Figures 1 to 8. The first shows the numbers of students from the experimental (labelled "special") and control groups completing each semester in their original curricula; it also lists the disposition of the others. Two results are apparent. First, students who shift to other curricula do so much earlier from the special group; in fact, for them, these changes are essentially completed after the first semester. Shifting students from the control group make their transfers later. Second, fewer students from the special group leave the curriculum of their original choice. It might be noted here that most shifts to other curricula are to less demanding ones (one reason for transferring is fear of failure). A word must be added concerning the entries labelled "in D.I.R., D.O.C., or lost." The total numbers of students still in the University at the end of six semesters is approximately the same in both groups. The D.I.R. (Division of Intermediate Registration) and its successor, D.O.C. (Division of Counseling), have two purposes: one is to try to salvage students in scholastic trouble; the other is to provide students who are changing curricula with a home for one or two semesters while they make up deficiencies in courses required in the new curriculum. Since the separation of these two groups is not possible, it is only at graduation that the absolute measure of mortality will become evident.

In Figures 2 to 8, average grades for the two groups are reported. Points which represent averages of fewer than ten grades are so marked and are joined to others by dashed lines. The course designations, followed by the number of grades in each course, are given beneath the graph in each figure. The courses required of the students in the original curricula in each semester are underlined. The mathematics, physics, chemistry, and English-composition series are the most advanced offered in the University, so that courses not underlined can be presumed to be easier ones. The level of statistical significance of the difference in grade-average for each semester in each group of courses is written at the top of each graph. Only four (Figs. 3, 4, 5, 6) are significant at the 5% level or lower on the Student t-test. Usually (Table I), more significant differences were found in the individual required courses than in groupings of these courses with those taken by students who had left their original curriculum. For those students taking Physics 235 in the third semester, for example, those of the special group performed significantly better at the 5% level than those of the control group; but when students taking or repeating other physics or chemistry courses are grouped in with those taking the Physics 235, the significance level rises above 20%.

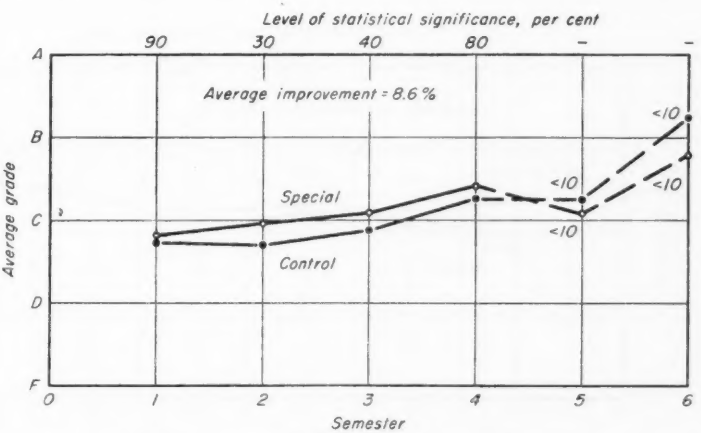
The use of the Student t-test in evaluating this experiment is open to argument. First, the population changes selectively from semester to semester.



Special						
In original curriculum -	24	16	14	11	12	11
In other curriculum -	0	4	5	5	6	7
In D.I.R., D.O.C., or lost -	8	12	13	16	14	14
Control						
In original curriculum -	26	24	14	7	6	5
In other curriculum -	0	0	2	6	9	12
In D.I.R., D.O.C., or lost -	6	8	16	19	17	15

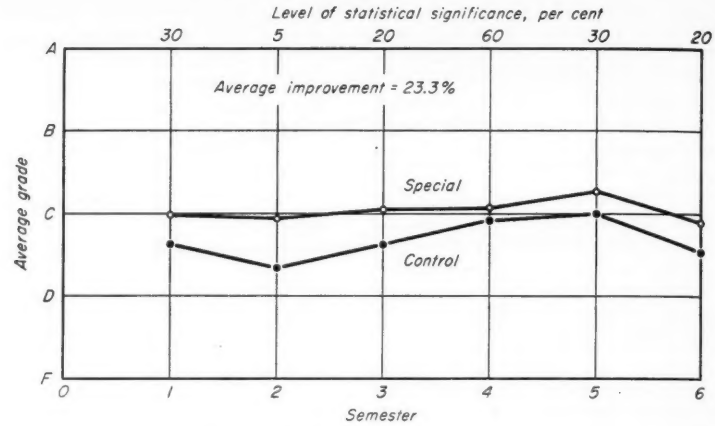
FIG. 1. Numbers of Students Completing Each Semester in Original Curriculum.

Second, the grade averages are constrained at both top and bottom, since no one can receive better than an A or worse than an F, so that differences of averages near the C level tend to be more significant than those near A or F. Third, grouping the grades as in Figures 2 to 8 may mean that a statistical unit (the student) may be represented more than once in some of the averages (for instance, in Figure 7, fifth semester, the same students took both Metallurgy 301



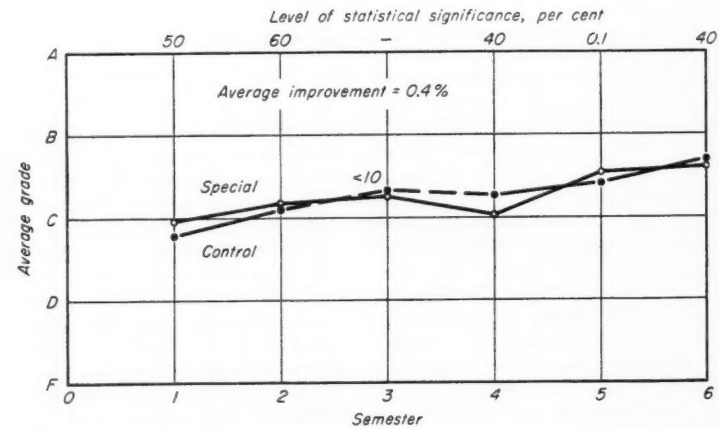
Courses, special -	math 41 (22) math 6 (6)	m 42 (15) m 41 (4) m 2 (2)	m 43 (12) m 42 (6) other (5)	m 44 (5) m 43 (5) other (3)	m 44 (3) other (6)	m 417 (3) other (3)
Courses, control -	math 41 (23) math 6 (6)	m 42 (18) m 41 (5) m 6 (1) m 2 (1)	m 43 (9) m 42 (6) other (2)	m 44 (6) m 43 (4) other (4)	m 44 (3) other (5)	other (3)

FIG. 2. Group I: Mathematics.



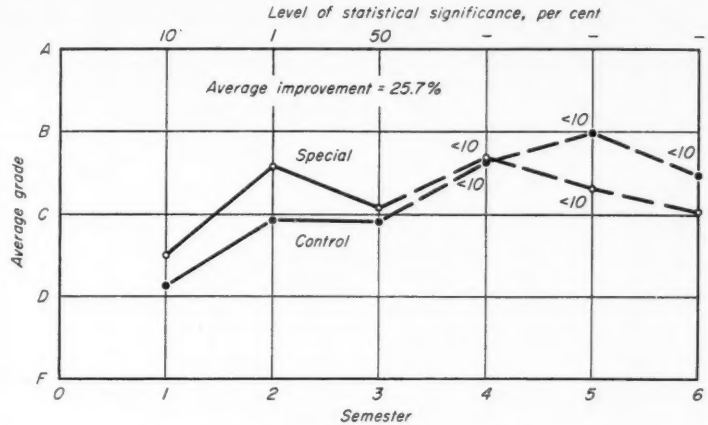
Courses, special -	chem 1 (23)	chem 2 (20) chem 1 (1)	phys 235 (14) other (4)	chem 20 (11) phys 285 (11) other (3)	chem 460 (11) other (3)	chem 461 (11) other (2)
Courses, control -	chem 1 (27)	chem 2 (21) chem 1 (5)	phys 235 (17) other (5)	chem 20 (9) phys 285 (10) other (6)	chem 460 (8) other (8)	chem 461 (5) phys 285 (4) other (5)

FIG. 3. Group II: Chemistry and Physics.



Courses, special -	comp 1 (19) comp 0 (9) (no grade)	comp 5 (20) comp 1 (5)	various (11)	various (28)	various (28) one each required	various (26) one each required
Courses, control -	comp 1 (19) comp 0 (10) (no grade)	comp 5 (21) comp 1 (4)	various (6)	various (32)	various (41) one each required	various (41) one each required

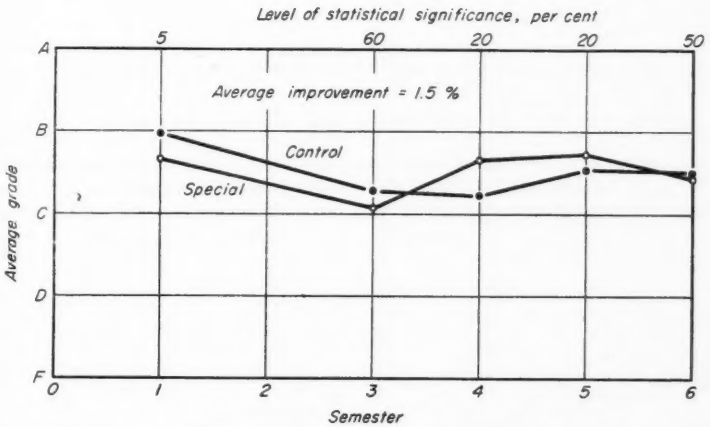
FIG. 4. Group III: Humanities and Social Sciences.



Courses, special - geol 31 (26) geol 32 (16) geol 31 (4) min 31 (16) other (2) meteo 300 (3) other (4) various (6) various (10)
one each required

Courses, control - geol 31 (29) geol 32 (19) geol 31 (4) min 31 (17) other (3) meteo 300 (3) other (6) various (5) various (8)
one each required

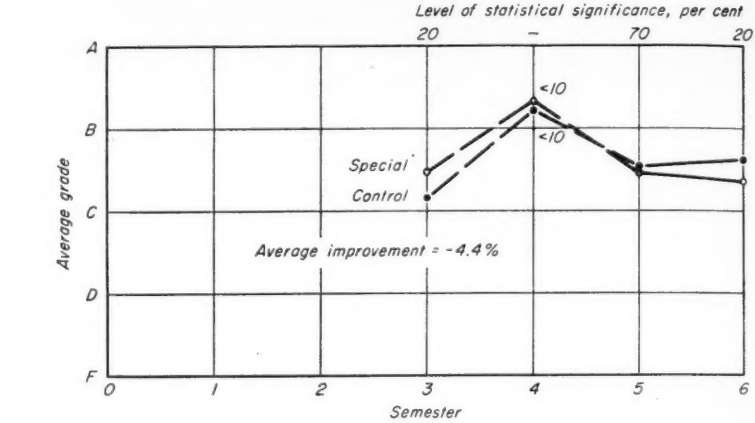
FIG. 5. Group IV: Other Sciences.



Courses, special - m i 1 (28) none mn pr 1 (16) other (2) e mch 11 (11) other (2) e e 8 (9) e e 8L (8) other (8) e mch 13 (9) other (6)

Courses, control - m i 1 (29) none mn pr 1 (15) e mch 11 (10) other (2) e e 8 (7) e e 8L (7) other (10) e mch 13 (4) other (10)

FIG. 6. Group V: Engineering.



Courses, special - none none or met 200 (9) / cer t 201 (6) / other (1) geol (7) other (2) [met 301 (8) / met 303 (6) / cer t 301 (4) / cer t 302 (4) / other (15)] or [met 302 (7) / met 304 (7) / met 60 (7) / cer t 303 (3) / cer t 304 (3) / cer t 57 (3) / other (24)]

Courses, control - none none or met 200 (13) / cer t 201 (4) / other (3) geol (2) other (4) [met 301 (5) / met 303 (5) / cer t 301 (2) / cer t 302 (2) / other (14)] or [met 302 (3) / met 304 (3) / met 60 (3) / cer t 303 (2) / cer t 304 (2) / cer t 57 (2) / other (26)]

FIG. 7. Group VI: Professional.

TABLE 1

GRADE AVERAGES FOR STUDENTS TAKING REQUIRED COURSES ONLY, IN THE NORMAL SEMESTER ONLY, IN PHYSICS, MATHEMATICS AND CHEMISTRY SERIES

Course	Sem.	Special		Control		Difference % of Control	Significance at % Level
		Ave. Grade	No.	Ave. Grade	No.		
Math 41	1	1.95	21	1.91	23	2.1	50
Math 42	2	1.67	15	1.71	17	2.3	50
Math 43	3	1.75	12	1.67	9	4.8	40
Math 44	4	2.83	6	2.57	7	10.1	30
Chem 1	1	2.00	24	1.64	28	21.0	10
Chem 2	2	1.89	18	1.42	19	33.1	10
Chem 20	4	2.42	12	2.11	9	14.7	20
Chem 460	5	2.45	11	2.37	8	3.4	40
Chem 461	6	2.18	11	2.00	5	9.0	40
Phys 235	3	2.15	13	1.41	17	52.5	5
Phys 285	4	1.91	11	1.80	10	6.1	40

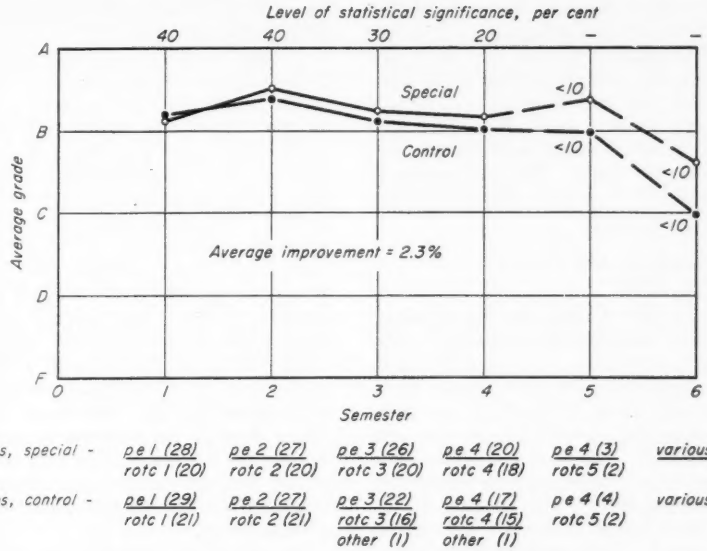

Level of statistical significance, per cent
40 40 30 20 – –
A
B
C
D
F
Average grade
Special
Control
<10
<10
<10
<10
Average improvement = 2.3%
0 1 2 3 4 5 6
Semester
Courses, special - pe 1 (28) rotc 1 (20) | pe 2 (27) rotc 2 (20) | pe 3 (26) rotc 3 (20) | pe 4 (20) rotc 4 (18) | pe 4 (3) rotc 5 (2) | various (3)
Courses, control - pe 1 (29) rotc 1 (21) | pe 2 (27) rotc 2 (21) | pe 3 (22) rotc 3 (16) other (1) | pe 4 (17) rotc 4 (15) other (1) | pe 4 (4) rotc 5 (2) | various (4)

FIG. 8. Group VII: Physical Education and R.O.T.C.

and 303). And fourth, especially in later semesters, the grades are averaged for courses of different difficulty (for instance, in Figure 3, fifth semester, the special-group average includes 11 grades in Chemistry 460 and 3 in easier chemistry or physics courses, while the control-group average includes only 8 grades in Chemistry 460 and 8 in easier courses). When the grouping is not done, and only the grades in the required courses (underlined in the figures) are averaged, the differences in performance between the special and control groups remain high in successive semesters (see Table I); this trend is lost by grouping, presumably for the reason given in the preceeding sentence.

One other measurement was made; it is reported in Figure 9. It is an attempt to establish the changing average intellectual competence of the students remaining in their original curricula. For this purpose the 4-part totals in the Moore-Castore scholastic aptitude test are used.

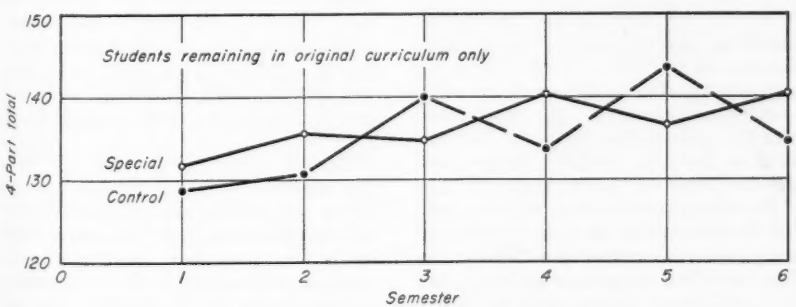


FIG. 9. Measure of Learning Capacity.

This test is given to the freshmen before the first semester begins. As the student population of each of the two groups changes, the average of their initial aptitude also changes. It is seen in Figure 9 that the average aptitude of the two groups grows at about the same rate and is about the same. The differences in aptitude are all statistically insignificant at the 0.5% level.

Modifications and Results in 1956–1958

In the fall of 1956 the experimental treatment was given to all students entering the curriculum of Metallurgy and to a few freshmen from the Ceramic Technology and Fuel Technology curricula. Improvements in teaching technique were incorporated. The class was divided into two sections of approximately equal size, one meeting from 8 A.M. to 10 A.M., the other from 1 P.M. to 3 P.M. Two results were noted. First, perhaps by virtue of the teacher's year of experience, the grades received by the students were higher in all courses than they had been for either group the year before; in particular, the average of the grades obtained by these students in the two examinations in the course "Mineral Industries Lecture" was higher than for the rest of the freshmen in the College, even though the special group took these examinations without benefit of the 14 lectures the others had heard on the subject matter. This difference occurred again in 1957.

In that third year, the experiment, applied again to all the freshmen in Metallurgy and to a handful of others, was conducted by two teachers, the experienced one having a class of 23 students, the new one two classes, 17 and 28 strong respectively. In the "Mineral Industries Lecture" examinations, the small class with the new teacher did some 5% better than the same teacher's larger class, and the latter did better than the class of the experienced teacher, which in turn did about as well as the non-experimental group from the rest of the College. A class-size effect is perhaps indicated, but the teacher's experience seems to be less important! None of the differences was statistically significant.

Finally, in 1958, two efforts were made to investigate the possibility of reaching larger numbers of freshmen in the University. First, the course substantially as described here was required of freshmen in one of the departments of the College of Agriculture. Second, 74 freshmen in the curriculum of Metallurgy were given the course over closed-circuit television. These students were divided into three groups of about equal size, in separate rooms. The teacher performs alone in an originating room. An upperclass student-proctor in each room has such minor functions as collecting papers and operating the "talk-back" system which permits the students to ask questions of the teacher. So far (the semester is only half gone at the time of writing) television seems satisfactory for this kind of instruction.

Success in the experiment in the College of Agriculture and satisfaction in the use of closed-circuit television would indicate that a substantial proportion of the first-year students in a University might benefit from such instruction, and that it could be given them at very little cost.

An additional project for future investigation is the introduction of a course of this type, but on a much more intensive basis (say, 4 hours per day for 3 weeks), just before the opening of the fall semester.

Need for Teaching University Students How to Learn More Effectively

There are at least three reasons why somehow the universities of the free world need to teach students how to learn. First, any student, having the innate capacity to benefit from higher education, and who has failed to complete a University course, becomes a misfit in our society.

Second, under the pressure of increasing enrollments in our schools and colleges, any student who begins but does not complete a university course is, while he is there, an economic drain on his parents, community, or State, depending on the source of his support; this eco-

nomic drain is not recovered, since his value to the economy is not significantly greater than if he had not entered the university. Third, as a result of the predicted increase in student/teacher ratio, the burden of learning cannot otherwise be kept in balance than by placing more of it upon the shoulders of the student. Perhaps a more important reason than any of these is the committment of a democratic society to develop to its greatest possible extent the capacity with which its sons and daughters were born.

The psychometric and empirical measurements of the intellectual capacity of a high-school senior are not altogether worthless, yet huge losses of students before their graduation continue to be the rule in our colleges, indicating either that admission procedures are very poor indeed or that something else is wrong. The results shown in this paper suggest that admission procedures are subject to no more than the human error found in any recruitment endeavor, and that the "something else" is a poor preparation of the high school seniors for learning from the universities' way of teaching. Some method of teaching them how to do so must be found and used. The technique here is but a meager start in the right direction.

CANDID COMMENTS

This section is open to comments on articles in the JOURNAL or on engineering education in general. Send comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

Professor W. T. Alexander's article, "Engineering Education, Experience and Expectations," in the October, 1959 issue of the JOURNAL was very stimulating. However, as a teacher and practising engineer, I do not fully agree with his Point 8 in the Summary (p. 14):

> We must increase the usage of higher mathematics in upperclass engineering courses.

I maintain that mathematics, higher or otherwise, is merely a tool, though admittedly a valuable tool, for the engineer. For certain kinds of work, higher mathematics is a necessity. However, for many others, its use is the "long way 'round." The engineering student should be trained to do his job the most efficient way, using the methods as tools only, not as ends in themselves. I am afraid that many teachers regard calculus and its relatives as "Sacred Cows" for all engineering students, somewhat as Latin used to be regarded for all liberal arts students. Why not save the higher mathematics courses (and teachers) for the students who really need them?

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The Role of Engineering in the Geophysical Sciences

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Oceanographic Institution, Woods Hole
Massachusetts

In February of 1959 the National Academy of Sciences made public a 500-page report by its committee on oceanography calling for an expenditure of $651,-410,000 in support of the marine sciences between 1960 and 1970. The report compared the military and political urgency of such a research effort to that of the conquest of space and indicated that the problem of the oceans was at least as exigent as that of outer space. Some disturbing facts were presented regarding the lead currently being maintained by the Soviets in the marine sciences.

The committee is absolutely right in its contentions on all counts. There is a favorite story among oceanographers about a mad scramble to get to Mars. All funds were funneled into this one gigantic effort to get a landing party on Mars, and the marine sciences were left to forage on their own on the forgotten planet Earth. The flight to Mars was a brilliant success—except the planet was found to be completely covered by an ocean.

Despite the tendency to focus upon the more spectacular outer space programs which make headlines almost daily, we are not losing sight of the fact that we still know very little about geophysical things right here at home. In addition to man's inherent curiosity about his environment, his instinct for self-preservation in view of an ever increasing population and global threat will force him to the oceans for food and energy and for protection against submarines with their awesome payloads; the same driving force which compels him to ask "what" and "why" a thousand miles up leads him to pose the same questions a thousand miles beneath his feet. He has not yet written off his knowledge of the atmosphere, but rather he has the first chapter yet to complete. Indeed, the earth satellite program promises to be a most powerful tool in the expanding field of meteorology and atmospheric physics.

We are, therefore, going to see an increasing emphasis on geophysical research for which trained engineers and scientists (the distinction is becoming increasingly difficult to define) will be required. The objective of the present discussion is to recall attention to the fact that our present engineering graduates in all branches of engineering are fully capable of taking up positions in the earth sciences and that it is our responsibility in engineering education to indicate to them the opportunities available. The implication here is that we have not in the past emphasized these opportunities to a very great degree.

How might an engineering graduate in civil, mechanical or electrical, say, fit into a program of geophysical research? By way of illustration I would like to discuss the field of oceanography in view of possessing some degree of familiarity with this fascinating science. We need only to state some of the problems involved to answer our question forthwith.

One of the principal areas of interest in oceanography has always been to gain an insight into the complicated dynamics of the circulation of the oceans. Such knowledge has assumed especial import in this atomic age inasmuch as we look to the oceans for a huge wastebasket into which we may discard radioactive wastes. The determination of sub-surface ocean

currents involves in part the measurement of very low velocities at very great depths from a vessel whose absolute position in space must be known with great accuracy. There are some extremely challenging problems here for the mechanical and electrical engineer. Surface currents are being measured by means of drift buoys harboring some pretty sophisticated electronic equipment by means of which the buoy may be interrogated from an airplane, located by a homing signal propagated from the buoy, interrogated again for temperature or other data, and the process repeated at a later date. Successive positions of the buoy define the mean surface current.

Another important problem is concerned with the propagation of sound in the ocean, not only from the standpoint of its use in charting the ocean floor but as a source of submarine detection. Indeed, the missile-carrying submarine promises to be the most difficult to defend against, and improved methods of detection will have to be forthcoming. Both the electrical engineer and the physicist play an important role here. Of course not all sounds in the ocean are made by man, and the study of fish noises has assumed a prominent position not only from the point of view of the detection problem but also from the marine biological standpoint. These sound measurements will require improved instrumentation.

We have taken to the oceans for food and a limited amount of other natural resources for a long time, but the future will see a sharp increase in our exploitation of the waters of the earth. Fish will be herded like cattle, huge submarine gardens will flourish on the ocean floor, minerals will be mined, and fresh water converted from sea water on a large scale to replace our already dwindling supply. There are several conversion plants now operating. All of these projects will present some fascinating albeit formidable engineering difficulties for engineers from all branches of engineering.

Surface Problems and Above

Not all oceanographic activities are confined to the depths but rather they relate to surface or near-surface phenomena as well. The engineer trained in fluid mechanics will find a host of complex problems to tax his ingenuity in this area, among which are studies of surface waves such as the mechanism of their generation, problems of wave measurement and the reduction of data to directional wave spectra (a considerable amount of electronics is involved here), the response of ships to an irregular seaway on both a model and prototype scale, and the mechanism of beach erosion. The problem of harbor design is of course related to wave motion and this is quite properly the bailiwick of the civil engineer. Much remains to be learned about the phenomenon of density currents and the so-called salt wedge as well as the mechanics of estuarine mixing.

The oceanographer's ocean also includes the atmospheric "ocean" surrounding our planet for there is a continual interchange of matter and energy between ocean and atmosphere and it is impossible to divorce the two. Cloud physics assumes an important role here as well as the study of hurricane formation and the knowledge of storms at sea from which wave forecasts may be made. The reader does not need to be reminded that both the hydro- and aerodynamicist would be at home relevant to problems of the motion of the atmosphere.

It may be of interest to enumerate the various categories of technical training represented at the Woods Hole Oceanographic Institution to illustrate how broad the spectrum of endeavor is as it applies to one of the basic geophysical sciences. Such a classification includes physicists, mathematicians, geologists, marine biologists, biochemists, chemists, meteorologists, naval architects, civil, mechanical, electrical and chemical engineers, zoologists, photographers, a pilot and crew for a research aircraft, and officers and crew for four major research vessels. Oh, yes—oceanographers work there, too.

I believe that we in engineering education should emphasize to a greater degree than we have been doing the nature of the work involved in the various geo-

physical sciences and the opportunities for engineers that are now available and will continue to be available to an increasing degree in the future. More difficult to convey, perhaps, is the deep sense of satisfaction—and wonderment—one receives from each new discovery about the world we live in and from the realization of what a beautiful piece of engineering planet Earth really is.

NSF TO AUDIT SOME GRANTS

The National Science Foundation has announced that it will soon initiate a program of auditing its various grants at colleges and universities. Audits will be conducted on a selective testing and sampling basis and will be concerned primarily with the financial and related aspects of the grants. They will not be concerned with such things as evaluation of the scientific procedure used or the quality of research performed. The primary objective of the audit program will be the development of sufficient experience to determine whether the auditing of research grants is necessary on a continuing basis. Institutions receiving Foundation grants will be notified well in advance of any audits scheduled.

"In order to interfere as little as possible with the administrative workload of institutions, the Foundation proposes to initiate its grant-auditing program on a highly selective and sampling basis," said Alan T. Waterman, Foundation Director, in commenting on the new audit plan. "The auditing of grants to institutions is part of a larger program of internal auditing established within the Foundation in order to fulfill its responsibilities as a Federal Agency for adequately safeguarding and economically utilizing the funds appropriated to it."

In announcing the plan for auditing grants, Dr. Waterman emphasized that the audits would be concerned "with financial and related transactions, and not with the substance of science involved in any grant."

Dr. Waterman pointed out that when Foundation resources for supporting its various scientific programs were smaller, a reasonably effective audit could be managed within the framework of the Foundation's fiscal regulations and procedural instructions. Such regulations and instructions are not adequate, however, to meet the audit requirements imposed by its current budget of more than $100,000,000 in support of basic research and education in the sciences.

"Our purposes in establishing the audit program are clear," said Dr. Waterman. "The Foundation has an obvious responsibility not only for assuring that its appropriations are used wisely and in accordance with the policies of the Foundation but also that grants are administered with the flexibility and freedom from undue restrictions necessary to allow research to be conducted most effectively. In carrying out these responsibilities, it is important not to interfere with the actual research or other scientific activity being carried on in institutions of higher learning. We believe that the grant-audit program we are establishing will accomplish these objectives and that in addition it will assist the Foundation in improving its administration of grants. Improvement in this area should result in additional savings in time and money in the administrative offices of the colleges and universities."

Engineering Guidance Assistance to Secondary Schools

A. PEMBERTON JOHNSON

Chairman of the Selection, Guidance and Placement Committee of the Engineering College Administrative Council of the ASEE *

The American Society for Engineering Education, as a member society of the Engineers' Council for Professional Development, has supported and encouraged the development over many years of the well-organized national, regional, state and local guidance committees of ECPD. The continuing need for more and better engineering guidance services to the secondary schools is indicated by the increasing variety of services supplied by the ECPD Committees and other interested groups.

In some instances, interested individuals, local groups and societies not associated with ECPD and unaware of its coordinative role, have undertaken engineering guidance at the local level without consulting either an ECPD state or local committee or an administrative officer of an ASEE institution. Sometimes activity of this kind has led to annoyance or confusion of secondary school personnel because of contradictory and unreliable information, whereas coordination through the well-informed ECPD Committes, which are representative of the engineering profession as a whole, minimizes these difficulties and makes possible wide dissemination of dependable guidance information.

Therefore, as one means of strengthening the coordinative role of the ECPD national, regional, state and local committees, the ASEE–ECAC Selection, Guidance and Placement Committee has passed the following resolution which has the approval of the ECAC Executive Committee:

The ASEE–ECAC Selection, Guidance and Placement Committee urges all members of the American Society for Engineering Education to aid, wherever possible, the appropriate local, state, regional and national committees of ECPD in their coordination of engineering guidance activities designed to assist secondary school personnel.

Guidance Committee Chairmen

The ECPD Guidance Committee chairmen for 1959–60 are named below.

National Chairman:
Mr. F. J. Jeffers
Baltimore Gas and Electric Company
Westport Service Building
Baltimore 3, Maryland

Regional Guidance Committees—ECPD 1959–1960

Region I

Donovan, Prof. E. T., Chairman
Mechanical Engineering Dept.
University of New Hampshire
Durham, N. H.

Connecticut
Sutherland, George
Park Road
Woodbury, Conn.

Maine
Evans, Dean W. S.
School of Engineering
University of Maine
Orono, Maine

Massachusetts
Bogan, R. T.
Planning Engineer
Monsanto Chemical Co.

* Dr. S. Paul Shackleton, now of the W. L. Maxson Company in New York, a past chairman of the ECPD Guidance Committee, was of great assistance in developing this statement.

Plastics Division
Springfield 2, Mass.

New Hampshire
Faiman, Dean Robert N.
College of Technology
University of New Hampshire
Durham, New Hampshire

Rhode Island
Stockard, R. H.
Director of Placement
University of Rhode Island
Kingston, R. I.

Vermont
McKee, Edd R.
Dean of Engineering
University of Vermont
Burlington, Vt.

Region II

Roemmele, Prof. Herbert F., Chairman
Placement Officer
The Cooper Union
Cooper Square
New York 3, N. Y.

New Jersey
Dinsmore, Thos. L.
Thos. A. Edison Research Laboratory
McGraw Edison Co.
Watchung Ave.
West Orange, N. J.

New York
Hilbert, E. A.
Aeronautics and Ordnance
General Electric Co.
Schenectady 5, N. Y.

Co-Chairman
Miller, Charles
Consolidated Edison Co.
4 Irving Place
New York 3, New York

Region III

Seeley, D. M., Chairman
U. S. Steel Corp.
525 William Penn Place
Pittsburgh 30, Pa.

Delaware
Degnan, T. F.
E. I. DuPont De Nemours & Co.
Louviers Bldg.
Wilmington 98, Del.

District of Columbia
Cole, Ralph I.
Melpar, Inc.
3000 Arlington Blvd.
Falls Church, Va.

Maryland
Gillett, John B.
Whitman, Requardt and Associates
1304 St. Paul St.
Baltimore 2, Md.

Pennsylvania
Colburn, George M.
U. S. Steel Corp.
525 William Penn Place
Pittsburgh 30, Pa.

Region IV

Lampe, J. Harold, Chairman
Dean of Engineering
North Carolina State College
Raleigh, N. C.

Alabama
Cudworth, Dean James R.
College of Engineering
University of Alabama
University, Alabama

Florida
Reed, John C., Head
Dept. of Mechanical Engineering
University of Florida
Gainesville, Fla.

Georgia
Staton, Dr. R. T .
Asst. Dean of Engineering
Georgia Institute of Technology
Atlanta 13, Ga.

Mississippi
Kellogg, Dr. F. H.
Dean of Engineering
University of Mississippi
University, Miss.

North Carolina
Whitfield, J. K.
Prof. of Mechanical Engineering
North Carolina State College
Raleigh, N. C.

South Carolina
Flinsch, Dr. Harold von N.
Head, Civil Engineering Dept.
University of South Carolina
Columbia, S. C.

Tennessee
Henderson, Prof., H. M.
Director, School of Engineering
Tennessee Polytechnic Institute
Cookeville, Tenn.

Virginia
Whittemore, J. W., Dean
Engineering and Architecture
Virginia Polytechnic Institute
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Region V

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General Motors Corp.
3044 West Grand Blvd.
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Indiana
Kronmiller, C. W., Manager
General Purpose Transformer Engrg.
Specialty Transformer Dept.
General Electric Co.
1635 Broadway
Fort Wayne 2, Ind.

Kentucky
Shaver, Dean R. E.
College of Engineering
University of Kentucky
Lexington, Ky.

Michigan
Coley, Glenn
The Engineering Society of Detroit
100 Farnsworth
Detroit 2, Mich.

Ohio
Stock, R. P., Manager
Works Technical Group
B. F. Goodrich Co.
Akron 18, O.

West Virginia
Johnston Ross B.
P.O. Box 249
Charleston 21, W. Va.

Region VI

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Engineering Dept.
Marquette University
1515 W. Wisconsin Ave.
Milwaukee 3, Wis.

Illinois
Harrington, J. Earl
910 Lake Shore Drive
Chicago 11, Illinois

Iowa
Fisher, G. F.
Stanley Engineering Co.
Hershey Bldg.
Muscatine, Iowa

Minnesota
Griffith, Leroy A.
Minneapolis-Honeywell Regulator Co.
2835 Nicollet Ave.
Minneapolis 8, Minn.

Missouri
Bryan, W. E., Secretary
Engineers Club of St. Louis
4229 Lindell Blvd.
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Nebraska
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North Dakota
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2305 Seventh Ave., North
Grand Forks, N. D.

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Emerson, William, President
South Dakota Society of
Engineers and Architects
Aberdeen, S. D.

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4323 North 14th Ave.
Phoenix, Ariz.

California
Northern
Ries, Harold C.
Shell Development Co.
Emeryville, Calif.

Southern
Milmoe, Robert
Bechtel Corp.
P. O. Box 58424
Los Angeles 58, Calif.

Idaho
Moser, Prof. D. H.
Head, Engineering Dept.
Northern Idaho Junior College
Coeur d'Alene, Idaho

Montana
Schilling, Dean E. W.
College of Engineering
Montana State College
Bozeman, Mont.

Nevada
Blodgett, Dean H. B.
College of Engineering
University of Nevada
Reno, Nev.

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Osipovich, A. A.
Professional Engineers of Oregon
4303 S. E. Knapp Street
Portland 6, Ore.

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Borg, Grant K.
Prof. and Head of Civil Engrg. Dept.
University of Utah
Salt Lake City, Utah

Washington
East
Landerholm, Ralph
Ken Woods & Associates
Hutton Bldg.
Spokane, Wash.

West
McNeese, Prof. D. C.
General Engineering Dept.
University of Washington
Seattle 5, Wash.

Region VIII

McGuire, J. G., Chairman
Assistant to Dean of Engineering
Texas Agricultural and Mechanical College
College Station, Texas

Arkansas
Imhoff, John L.
Prof. & Head, College of Engineering
University of Arkansas
Fayetteville, Ark.

Colorado
Dobrovolny, Ernest
Engineering Geology Branch
U. S. Geological Survey
Building 25, Denver Federal Center
Denver, Col.

Kansas
Rose, Kenneth E., Head
Dept. of Mining and Metallurgical Engrg.
University of Kansas
Lawrence, Kan.

Louisiana
Gaddy, William C.
Esso Standard Oil Co.
Baton Rouge, La.

New Mexico
Bothell, Dr. L. E.
Sandia Corp.
Sandia Base
Albuquerque, N. M.

Oklahoma
Lohmann, Dean M. R.
College of Engineering
Oklahoma State University
Stillwater, Okla.

Texas
Green, Col. Thos. C.
Executive Secretary
Texas State Board of Registration for Professional Engineers
308 West 15th St.
Austin 1, Texas

Wyoming
Mullens, Glenn B.
Assoc. Prof. of Civil & Architectural Engrg.
University of Wyoming
Laramie, Wy.

Outside Continental U. S.

Canada
Young, Donald A., Chairman
Asst. to Vice President
Foundation of Canada Engineering Corp., Ltd.
1900 Sherbrooke St., West
Montreal, Quebec
Home: 5270 O'Bryan Ave.
N.D.G., Montreal, Quebec

NEW DEAN AT CALIFORNIA

Dr. John R. Whinnery, professor of electrical engineering, has been appointed Dean of the College of Engineering on the Berkeley campus of the University of California, Chancellor Glenn T. Seaborg has announced.

Dr. Whinnery succeeds Dean Morrough P. O'Brien, who retired from the position on June 30 after 15 years as head of the College.

Student Leadership Training in the Laboratory

RAYMOND C. HALL

Assistant Professor of Chemical Engineering
Kansas State University

Leadership is generally recognized as a desirable quality for success in engineering. Many industrial concerns include questions pertaining to leadership or potential leadership on the evaluation scale which they ask former teachers and associates of a prospective employee to complete. Thus development of leadership is generally recognized as a valid objective in college training. Such an objective must not cause any de-emphasis on the primary objective of technical training in the engineering curriculum; it would be desirable if the two could be made to complement one another. This note presents a method of laboratory organization which combines these two objectives.

A total discussion of leadership is beyond the scope of this paper. Let us consider only three of the many components which must be blended together to compose the whole of mature leadership: 1. responsibility, 2. technical competence, 3. self confidence.

The engineering laboratory is an excellent place for the student to gain experience in leadership. Usually, in such laboratories, the student works with realistic types of equipment. He should have an understanding of the theory involved, of the principles of operation, of the data which could be taken, of those variables which are more important, of what "readings" must be taken and what degree of accuracy each reading requires. Frequently, several readings must be taken at a common time. Data must be recorded. Certain preparations should be completed before the start of the laboratory: bearings should be greased, high temperature furnaces should be turned on, standard measurement references should be in order and so on.

Group Experiments

It is common practice to organize the laboratory into groups. One man of the group is assigned as "leader." He is expected to assume the major responsibilities of organization, operation, calculation and report writing for the experiment. So this student, if he is a conscientious and an intellectually strong individual, will work very hard in preparation. He will dig out all the written material which he can find and will study to the very end. Then he comes to the laboratory period all primed with technical knowledge. He assigns each member of the team to specific duties. He starts the experiment, turns on the switch and a fuse blows. He has forgotten some apparently rather "minor" aspect of the "practical" part of the experiment; or perhaps the pump which handles the slurry is stuck because of solids in the retained liquids settled out and fowled the valves after the last class used it. Some of this type of experience is good, but it can and does become disheartening and discouraging after it has happened several times. The leader becomes discouraged and the members of the operating team become disgruntled.

On the other extreme, the instructor himself may assume the real responsibilities for the effective operation of the laboratory. In this case a type of artificial or fictitious "responsibility" is placed on the student leader.

It could well be that this latter alternative does more harm than good. If the student receives credit for assuming responsibility which in reality has been assumed by the instructor, one cannot help but fear as to the long range consequence. Is he being taught the kind of responsibility which constantly leans on a superior, so that he becomes afraid to accept complete responsibility for finishing the job? Is he being taught to accept credit for that which does not rightfully belong to him? Crawford H. Greenewalt has said, "By giving one individual a mortgage on the efforts of another, we execute

TABLE 1

GROUP ORGANIZATION SCHEDULE

Laboratory Session	Team Position	Exp. V	Exp. VI	Exp. VII	Exp. VIII
1 or 6	Leader (acting)	K_1	S_1	U_1	M_1
	Asst. Leader	K_2	S_2	U_2	M_2
	Operators	K_3, K_4	S_3, S_4	U_3, U_4	M_3, M_4
2 or 7	Leader	K_2	S_2	U_2	M_2
	Asst. Leader	M_3	K_3	S_3	U_3
	Operators	M_4, M_1	K_1, K_1	S_4, S_1	U_4, U_1
3 or 8	Leader	M_3	K_3	S_3	U_3
	Asst. Leader	U_4	M_4	K_4	S_4
	Operators	U_1, M_2	M_1, K_2	K_1, S_2	S_1, U_2
4 or 9	Leader	U_4	M_4	K_4	S_4
	Asst. Leader	S_1	U_1	M_1	K_1
	Operators	U_2, U_3	M_2, M_3	K_2, K_3	S_2, S_3
5 or 10	Leader	S_1	U_1	M_1	K_1
	Asst. Leader	S_2	U_2	M_2	K_2
	Operators	S_3, S_4	U_3, U_4	M_3, M_4	K_3, K_4

a twin injustice. One we deprive of the fruits of his labors and the rightful regards of his industry and thrift. The other we deprive of his sense of responsibility. In the long run I am not sure who suffers the greater loss."

Thus the problem which confronts the instructor who desires to incorporate leadership training into the laboratory work seems to be, in large part, associated with the degree of responsibility which he can place on the student. With high degree of responsibility on the student leader less effective laboratory results may be expected: a minimum of responsibility will give better laboratory results but at the expense of effective leadership experience.

A New Approach

A new approach to this problem was attempted during the second half of the fall semester of 1957 in the chemical engineering laboratories of Kansas State University.

The laboratory met once a week for a three hour session. There were about sixteen men in each class. Four experiments were performed during the first half of the semester. A report was required from each man on each experiment. A systematic schedule was prepared before the first session, one man of each group was appointed as leader for each experiment, and the leaders were rotated so that each man served as leader on one experiment. This schedule was reproduced and a copy given to each student in order that he could know well in advance when he was to serve as leader. This system worked out about as well as could be expected. The instructor found it necessary to work closely with all groups at all times.

During the second half of the semester a new approach to preparing the leaders for their duties was formulated and given trial. It was based upon a practice which is frequently employed in industry where a man serves as an assistant to an executive before he is expected to assume the real responsibility himself.

Four groups of four men each were organized as before. One man was designated as leader, a second man was designated as assistant leader and the other two were called operators for each experiment. The assistant leader helped the leader to organize and conduct the experiment.

A study of Table 1 will serve to clarify the organization and the procedure for

rotation of duties. Groups were initially designated with letters (K, S, U, and M) and members within groups were assigned identifying numbers (1, 2, 3, 4). Each man retained this same letter and number designation throughout the remainder of the semester.

For laboratory session 6, group K performed experiment V, group S performed experiment VI and so on. Member number 2 of each group was assistant leader during this first session and served as leader for the same experiment during session 7. A man (number 1) was designated as acting leader for each experiment during session 6. This man was notified of this responsibility and he worked closely with the instructor in preparing himself for the experiment; much as he would have done during the first half of the semester. The real responsibility for the success of the experiment lay with the instructor hence the title "acting leader" was given to this student.

Member number 2 was allowed considerable freedom in his duty assignments. He knew that he was to serve as leader for this same experiment at the next laboratory period. Accordingly his efforts and observations were directed toward considerations of how he could best organize for the next week. He noted such items as a) which problems presented specific complications, b) where weak points were in the equipment, c) where directions fell short or were not clear, and so on. He was not required to write a report, as were all other members of the team, but was allowed to use his time, as he best saw fit, in preparation for his own leadership responsibilities. He could, if he wished, aid the others in analysis of their data and/or preparations of their reports. Such activities provided realistic experiences and served as a valid basis upon which to prepare for his own leadership position.

Duties within the groups and members between groups were rotated, as indicated in Table 1, on subsequent experiments.

After the first week the instructor was available when needed. Actually he was needed very little.

One of the real rewards of teaching is the progress which the instructor can observe in the student. This experiment in class organization was highly gratifying. The leaders assumed responsibilities in a very realistic sense. Actually, except for items of supply where purchase was involved, the instructor was not consulted after the second week. The men seemed to enjoy their positions of leaders. The quality of the reports improved. The number of late reports dropped to only one or two per week as compared with about five per week during the first half of the semester. In general a superior attitude toward the laboratory work seemed to develop and to prevail among the students.

The major disadvantage to this system of organization was that each student missed one experiment when only four laboratory periods were allowed for the four experiments. This could have been overcome by allowing an additional week (session no. 10) as shown in Table 1.

Conversation with various students left the instructor with the following impressions:

1. Most students appreciated the opportunity to assume real responsibility provided they are allowed to prepare for it.

2. This system provided an opportunity for a man to gain experience before he was asked to assume leadership.

3. Since the leader had an opportunity to gain this experience, he held an "edge" over other members of his operating team. He was better prepared than the others and his self-confidence in his abilities to properly lead the group was enhanced.

It would thus appear that the opportunity to gain superior technical and practical know-how (i.e. technical competence) built up the self-confidence of the individual. Once the self-confidence was established, the individual was willing, even anxious, to assume the real responsibilities. Thus, workable training and realistic experience in leadership were obtained.

Decrease in demands on the instructor's time (in view of the developing shortage of college teachers) is a valuable by-product of the method.

Engineering Economy Courses in Educational Institutions

GERALD J. MATCHETT

Professor of Economics and Director of the National Center for Education and Research in Equipment Policy, Illinois Institute of Technology

Background of Survey

This survey is concerned with the extent to which courses in engineering economy and equipment replacement analysis are a part of the curriculum in our educational institutions. It was made under the auspices of the Engineering Economy Division of ASEE.

Recent evidence has pointed to a growing interest in industry in the application to business problems of engineering economy methods—particularly methods relating to equipment justification. For example, a survey conducted in the capital goods industry by the Machinery and Allied Products Institute revealed an increasing awareness of the importance of applying analytical techniques systematically to facility renewal problems.[1] As reported in this survey, to the question, "Do you have an individual or staff with special responsibility for the preparation of studies to determine the economic advantage of re-equipment?", 54% of the firms responding replied "yes" in 1956, whereas only 28% replied "yes" to a similar question in a 1948 survey. To the question, "Do you make a regular (either continuous or periodic) review of your equipment situation for the purpose of improvement and modernization?", 79% replied "yes" in 1956 and only 35% replied "yes" in 1948. This survey concludes:

> The outstanding impression gained from a comparison of the 1948 and 1956 surveys is that the past several years have witnessed the beginning of a revolution in what was, until recently, a backward area of management—equipment policy.

In view of this and other evidence of increasing industrial use of engineering economy techniques, the Engineering Economy Division of ASEE authorized a survey to determine the present status of courses in engineering economy in educational institutions.

Method of Survey

The survey consisted of two questionnaires. The first was sent to the dean or other appropriate official of each educational institution listed in the 1958 Yearbook-Directory issue of the JOURNAL and to an appropriate official in each additional institution listed in the *Education Directory of the Office of Education* as having an accredited engineering curriculum. The preliminary questionnaire asked for the names of individuals teaching engineering economy or equipment replacement policy either as separate courses or as parts of other courses and for the department involved in each case. The respondent was asked to check separately if such courses were not offered.

No attempt was made to define engineering economy precisely. Accompanying the questionnaire, however, was a one-page covering letter which contained the following paragraphs:

For purposes of this survey, Engineering Economy refers to techniques and methods

[1] *Equipment Replacement and Depreciation—Policies and Practices*, Machinery and Allied Products Institute, Washington, D. C., 1956.

Presented in preliminary form before the Engineering Economy Division of the American Society for Engineering Education, University of California, Berkeley, California, June 18, 1958.

for making decisions among engineering, business, and production alternatives. This survey will not cover general Principles of Economics courses designed for engineers unless portions of such courses are devoted to Engineering Economy or Equipment Replacement problems. Courses in Engineering Economy are frequently taught in Industrial Engineering or other standard engineering departments. They are sometimes given in Business and Economics departments or schools of business.

To facilitate this survey, I shall appreciate learning from you the name of the individual at your institution responsible for teaching courses or portions of courses in the fields described above, or if more than one department is involved, the name of the responsible person in each department. A detailed questionnaire regarding course content, materials used, and the like will then be sent to those designated by you. If you do not offer work in the indicated areas, information to this effect will also be valuable for purposes of our survey.

The second and major questionnaire, also accompanied by a one-page letter, was sent to each individual listed in the replies to the first questionnaire. A total of 16 questions was asked ranging from the course title, number of hours, annual enrollment, whether the course is required or elected, the level at which it is taught, and materials used to questions regarding graduate work in the field and also evening and extension programs.

Response to the Survey

The preliminary questionnaire was sent to 224 administrative officials; 200 replies were received. Of the 200 replies, 50, or 25%, replied that no courses in engineering economy or equipment replacement analysis were offered in their institutions. The remaining 150 replied that such courses were offered and listed the individuals to whom the detailed questionnaire should be sent. A number of the replies listed more than one individual.

Accordingly, detailed questionnaires were sent to 194 individuals in 150 institutions. In many instances, individuals in the same institution consolidated their replies so that 145 questionnaires were received from 128 institutions—a return from slightly over 85% of the 150 institutions to which questionnaires were sent. This high response is an indication of the interest in the subject in educational circles.

Statistical Results

A single questionnaire was received from each of 116 institutions. From 12 institutions, 29 questionnaires were received from individuals in different departments, bringing the total number of individual responses to 145. The first major question was whether or not an introductory course in engineering economy is offered. The results are as follows:

Replies	Institutions	
	Number	Per Cent
Yes	102	79.7
No	23	17.9
To be offered	2	1.6
Discontinued	1	.8

It is interesting to note that of the 128 institutions from which the detailed questionnaire was received, nearly 80% offer an introductory course and nearly 18% offer no such course. To interpret this result correctly, it must be remembered that 50 replies in the negative were received from the preliminary questionnaire. Thus out of 200 institutions 73 or nearly 37% offer no course in engineering economy.

Other results in response to specific questions asked in the detailed questionnaire are presented below. In general the figures are self-explanatory. It should be pointed out, however, that since more than one questionnaire was received from some institutions in which the course is offered in different departments, the number of replies exceeds the number of institutions in which the course is given. In addition, in response to certain questions more than one item might have been listed. For example, if a questionnaire indicated that engineering economy was required in two curriculums, two responses would be entered so that the total number of responses to a given question may exceed the number of replies (questionnaires).

Another interesting response was that given concerning the average annual enrollment in the engineering economy

	Number	Per Cent of Total Number
Course Titles (111 replies)		
Engineering Economy	56	50.5
Engineering Economics	15	13.6
Engineering Economic Analysis	3	2.7
Engineering Administration	3	2.7
Chemical Engineering Economy	3	2.7
Other titles (28)	31	27.9
Total	111	
Time Devoted to Course (113 replies)		
3 Semester Hours	58	51.3
2 Semester Hours	26	23.0
3 Quarter Hours	14	12.4
More than 3 Semester Hours	6	5.3
More than 3 Quarter Hours	5	4.5
Other	4	3.5
Total	113	
Department in which Course is Taught (114 replies)		
Industrial Engineering	34	29.8
Mechanical Engineering	22	19.3
Civil Engineering	17	14.9
Engineering and General Engineering	16	14.0
Industrial Management, Business, Economics	9	7.9
Electrical Engineering	6	5.3
Chemical Engineering	5	4.4
Other	5	4.4
Total	114	
Frequency with which Course is Given (111 replies)		
Once per year	47	42.5
Each Semester	35	31.5
Each Semester and Summer	12	10.8
4 Quarters per year	6	5.4
2 Quarters per year	6	5.4
3 Quarters per year	3	2.7
Less than once per year	2	1.8
Total	111	
Curriculum in which Course is Required (113 replies)		
All Engineering Curriculums	18	11.8
None	10	6.5
Civil Engineering	36	23.5
Industrial Engineering	33	21.6
Mechanical Engineering	23	15.0
Electrical Engineering	12	7.9
Industrial Management	6	3.9
Chemical Engineering	5	3.3
Other	10	6.5
Total	153	
Prerequisites (114 replies)		
Junior or Senior Standing	45	34.3
Principles of Economics	27	20.6
None	20	15.3
Advanced Economics, Accounting, and Business Courses	12	9.2
Calculus and Statistics	9	6.9
Other (mainly specialized engineering courses)	18	13.7
Total	131	
Text Materials Used (110 replies)		
Grant, Thuesen, Woods and DeGarmo	93	79.5
Other	24	20.5
Total	117	

course. A total enrollment of 9,945 students per year was reported in the 110 replies to the question. This averages 90 students per year, but the responses ranged from a low of three to a high of 600 students per year.

A specific question was asked as to whether equipment replacement policy is taught as a part of engineering economy. In view of the fact that practically all the texts in the field devote some space to this topic, the answers are not surprising. Out of 112 replies, 104 answered "yes" and only eight answered "no." A more significant question was one asking whether or not equipment replacement policy is taught as a separate course. Of the 100 replying to this question, only five answered in the affirmative, one replied with a qualified "yes," and 94 replied "no."

One question was asked to ascertain whether graduate work is available in engineering economy. Of the 110 responding to this question, 24 reported the availability of graduate work in the field, six reported the possibility of graduate work in research projects, and 80 replied that no graduate work is available.

A final question concerned the availability of courses in engineering economy and equipment replacement policy to industry personnel in evening or extension programs. This question drew 137 replies. A total of 89 indicated no evening or extension offerings in the field. However, 40 replied that such offerings are given, three indicated that offerings are available but seldom given, and five reported that evening or extension division work in the field is being contemplated.

Trends in Educational Practice

In order to evaluate present educational practice regarding courses in engineering economy, it would be most helpful if data were available that might indicate trends. Some information is available from a survey made by Professor William D. McIlvaine, Jr., in 1951.[2] In his study, McIlvaine reported that questionnaires were sent to 150 schools, that 122 returns were received, and that a detailed analysis was made of "the returns from the 57 schools that reported that they taught engineering economy and who gave sufficient information." Consequently, there is no figure from the 1951 survey comparable to the figure of 102 institutions out of 128 returns reporting teaching engineering economy in the present survey. The McIlvaine study, however, has an interesting table showing the curriculums in which the course is required. Since both surveys undoubtedly reflect what the major engineering schools are doing, a comparison is interesting.

CURRICULUM IN WHICH COURSE IS REQUIRED

	1951 Survey	Present Survey[3]
Civil Engineering	33	54
Industrial Engineering	26	51
Mechanical Engineering	24	41
Electrical Engineering	20	30

Given the fact that the 1951 survey contained only about 56% as many institutions returning replies that could be analyzed, the results are fairly consistent and show no trend toward making engineering economy a required course in more institutions. In fact from this point of view, electrical engineering shows up relatively less favorably in the present survey than it did in 1951. It is interesting to note that the four major curriculums requiring engineering economy appear in the same order in both studies. Thus, the first-listed conclusion in the McIlvaine study that "Engineering Economy is basic to engineering and should be required in the engineering curriculum" seems to have borne little fruit.

In the McIlvaine study, the 57 schools analyzed reported the average percentage of the students taking engineering economy to be 40.6. No such figure was obtained in the present questionnaire.

[2] William D. McIlvaine, Jr., "The Status of Engineering Economy," *The Journal of Engineering Education*, Vol. 43, No. 2, October, 1952, pp. 85–89.

[3] Since "All Engineering" is included separately in the present study, the total for each curriculum is increased by 18 over the figures previously presented. This leads to an overstatement because not all the 18 schools requiring the course in all programs have all the curriculums presented.

However, this survey shows an annual enrollment in the course of 9,945. According to figures compiled by the U. S. Office of Education, engineering schools conferred 31,216 undergraduate engineering degrees during the 1957–58 academic year. Based on these figures, nearly 32% of the engineering graduates would have had a course in engineering economy. Given the fact that the present survey did not receive a 100% response and given the fact that those not replying tended to be from the smaller institutions, the percentage of students revealed as taking engineering economy in the present survey is remarkably close to the 40.6% reported by McIlvaine in the 57 institutions analyzed by him.

A closer analysis of the questionnaires returned in the present survey reveals a few interesting facts which may be indicative of long term trends.

First, schools of business are beginning to introduce courses containing the subject matter of engineering economy in their industrial management programs. Although this survey did not cover schools of business *per se*, a few questionnaires were received from such schools. For example, the University of Chicago School of Business reported two courses in which the Grant book was used for a substantial portion of a quarter. The business schools at Cornell and Harvard reported courses in which equipment replacement analysis was particularly emphasized. This trend toward the introduction of engineering economy topics in schools of business is quite significant.

Second, there is a trend toward the introduction of more specialized courses in recent years. For example, the five responses indicating courses in equipment replacement policy indicate these courses to be fairly recent in origin.

Third, there seems to be a definite trend toward the possibility of more graduate work, if not through more advanced courses, at least through research projects and the admission of thesis topics in the general area.

Finally, it should be noted that many questionnaires were accompanied by detailed course outlines and long covering letters expressing great interest in the survey results. They indicated that many individuals present material to supplement the particular text they are using (in a few cases all the material presented is in mimeographed form) and that there is considerable thought being given to the course content. The letters expressed much enthusiasm for the subject, and one has the feeling that the field is truly in ferment. Some of the foregoing trends were deduced from the letters which were sent when the questionnaire was returned.

General Evaluation and Conclusions

The findings of this survey are rather impressive. Many teachers in many educational institutions are introducing each year a sizable group of engineers to the field of engineering economy. In addition, a few teachers in schools of business are beginning to introduce their students to the subject. These results, however, are not grounds for complacency when we realize that perhaps as many as two-thirds of our engineering graduates are not introduced at all to the field.

This is particularly unfortunate when one realizes that many engineering graduates (probably more than 50%) will ultimately hold positions of responsibility in industrial management. A substantial proportion of the remainder will be involved with some phase of project justification. Engineering economy more than any other single course in the curriculum serves to translate engineering training and background into useful industrial application from the management point of view.

Some of the most important management decisions involve economic feasibility. Management may wish to make a study regarding the justification of a new plant or its best location, or to make a study to determine whether or not the acquisition of a new facility or the installation of a new process is justified, or to determine the best economically among a number of projects in which the firm's capital may be invested. The individual best equipped to make such studies or to evaluate their results is one

with an engineering background versed in methods of economy studies. Of course the broader his background in accounting, cost analysis, statistics, and similar business and economic subjects, the greater the facility he will bring to his task, but the single most valuable course is the one in engineering economy. It cuts across departmental lines. It is useful to the chemical engineer as well as to the civil or industrial engineer. It presents the methods for taking engineering and technological data and subjecting these data to economic analysis. Thus, engineering economy is one of the truly integrating courses in the engineering curriculum. It provides a bridge between engineering training and industrial application to obtain answers to questions involving value analysis.

One can only conclude with McIlvaine's recommendation that ways and means should be explored for introducing the remaining two-thirds of our engineering students to a field which most of those who go into industry will probably be called upon at some time in their career to practice. This can be done in one of two ways: by making engineering economy a required course in all engineering curriculums or by making the course a *specific* elective available to students in their engineering program. If the latter alternative seems most practical, it is likely that, with attention called to the nature of the course, most students would elect it.

Given this point of view, the work of the Engineering Economy Division assumes added significance. Through its annual meetings and summer symposiums and through *The Engineering Economist*, a quarterly journal which it sponsors, it must seek new ways of calling the attention of educators, responsible for formulating engineering curriculums, to the practical contributions that courses in engineering economy can make to the education of engineers. The Division can also encourage, for students who desire them, the introduction of more specialized advanced courses, such as those in equipment policy or in project justification in which more of the theory is stressed. Further, it can emphasize the importance of offering graduate work in the field. In addition, it can seek ways of increasing the availability of evening and extension courses and in-service training programs for engineers in industry and other industry personnel who wish to learn more of engineering economy techniques or take even more specialized courses. Finally, the Division can help promote this program by continuing its interest in improving the quality of teaching and helping teachers keep abreast of latest developments in the field.

It was pointed out in the introduction to this article that there is evidence of a growing awareness on the part of industry of the importance of applying engineering economic analysis to problems involving the spending of capital funds. This new attitude on the part of management has been referred to as the beginning of a revolution in what was, until recently, a backward area of management. The big question is, will engineering schools keep apace with industry in placing greater emphasis upon training their students in the field of engineering economic analysis? [4]

[4] The author wishes to state that the views expressed in this conclusion are his own. These views are supported, however, by the response to the questionnaire and the many accompanying letters.

The author wishes to take this opportunity to thank the members of the Engineering Economy Division for their help in the difficult task of formulating a questionnaire. The author also wishes to express his appreciation to the 200 deans and other administrators who replied to the initial questionnaire and to the 145 individuals who filled in the detailed questionnaire. Of particular assistance were those who sent course outlines and other material and wrote enthusiastic letters which, indeed, proved infectious.

Effective Utilization of Staff and Facilities

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Academic salaries constitute a major cost of operating a large university. Cost studies of state institutions of higher learning in New Mexico found academic salaries to be about 75% of the total expenditures for instruction.[1] On the University of Washington campus a new Mechanical Engineering Building has been constructed and outfitted for a cost of about two million dollars. This facility and its equipment are the principal tools of 40 to 60 faculty members. We may assume conservatively that the service life of the building and most of its facilities will be over 50 years. During the next fifty years, about forty million dollars will be spent for salaries of the staff who used this building. The ratio of cost of staff to initial cost of facilities may then be estimated as roughly 20 to 1. Then, when considering the utilization of staff and facilities, it is economically more important that facilities are arranged to promote the most effective utilization of staff than to arrange staff assignments and classes to get maximum utilization of facilities.

To evaluate how effectively a teacher is used, let us turn to the classroom setting. Here we can make both quantitative and qualitative judgements. Qualitative characteristics to note are the ability of the teacher, the format of the course, the presence and appropriateness of teaching aids, etc. Such characteristics are hard to measure even on a relative basis. They are related to effective teaching but only indirectly related to effective utilization of staff. By observing the number of students enrolled in the class, the class limit, and the capacity of the facility, we can record numbers which have both instructional and economic implications. We should compare the enrollment in the class with the registration limit set for the class and compare the class limit with the limit of the facility. We should also take a close look at the class instructional limit assigned and ask why it is that specific number.

In comparing the actual enrollment in the class with this limit, we would find some classes not full. These situations may be completely justified or unavoidable, but in checking on effective utilization of staff and facilities, unused class space should be our *first* concern. The term *class fullness ratio* will be used here. I have defined it as the class enrollment divided by the class limit. When more than one class of a course is offered (multi-section courses), the average class fullness ratio should be high, approaching 1.00. High average class fullness ratios are observed when the class offerings are well planned. Good class forecasting techniques combined with good registration procedures and controls are essential.

In comparing the class instructional limit with the limit or capacity of the facility, we would find many classes assigned to rooms larger than necessary. Although we plan our new facilities carefully, they seem to be obsolete almost before we occupy them. In facilities over 25 years old, how were we to know when they were designed, of the improvements we were to make in our teaching methods, of our changing technology and curricula, and of the increasing enrollments we are facing. If, as previously presented, the cost of staff is high compared to the cost of facilities, class limit should seldom be determined by the capacity of the facility. An "extra" classroom chair need be used to accommodate a larger class but a few times

[1] John Dale Russell, and James I. Doi, "Analysis of Expenditures of Instruction," *College and University Business*, Vol. 20, No. 5, May, 1956.

to justify its initial cost. Using current costs and salaries it could be shown that in many cases the "extra" classroom chair provided today need be used in only six semester-classes in the next fifty years to make it a worthwhile investment. In every course where the instructional limit has been set lower than need be due to limited facilities, an economic study should be undertaken.

Scheduling

Statistics representing facility utilization should report not only how completely a facility is used when in use, but the amount of scheduled or unscheduled time. For example, a classroom might be reported to average 70% full while being used 18 hours per week. As the enrollment increases, facilities will naturally be used more effectively because the frequency of use will increase. The increased utilization in some areas may be somewhat offset by an increase in special facilities and new programs. Thus many teachers feel that engineering education is better in large schools, particularly in graduate work.

Efforts to increase class fullness ratios and facility utilization by improved methods of class forecasting and improved registration procedures and controls should be accompanied by careful reviews of the class instructional limits assigned. Class limit is the most fundamental factor in utilization studies. When examining a list of courses and corresponding class limits we would see large variations and apparent inconsistencies. Because teachers are so sensitive to class sizes, limit assignment is a controversial and difficult problem. The task is the responsibility of academic administrators and the assigned number represents the momentary balance between policy, economics, facilities available, enrollment and teaching format.

For Example

Let us review the points discussed so far by using a hypothetical case involving a sophomore course in Mechanisms. In one section of the course, 19 students are enrolled, the class limit is 20, and the classroom has seats for 28. The class fullness ratio is 19/20 or 0.95. This seems to be a very satisfactory situation, but we must compare this ratio with those of other sections of the same course and other courses of similar teaching format. The average fullness ratio for the department is needed to indicate the effectiveness of class forecasting and registration controls.

The ratio of limit on the class to facility limit is 20/28 or 0.71. Again, this figure has little meaning by itself and must be compared to the over-all average of similar facilities and the frequency of facility use.

The class instructional limit is 20 students. Does this mean that an enrollment of 20 students is the maximum number that may be taught this subject matter effectively using this teaching format? Or is it more of an optimum class size? To the clerical personnel involved in registering students, the class limit is usually considered to be the maximum enrollment allowed and can be exceeded only in special circumstances. One definition of optimum class describes a compromise between the quality and cost of instruction. By illustration, a class limit is 20, not 25, because the decrease in teaching quality would not be worth the decrease in the unit cost of teaching the larger class. Likewise, the limit is 20, not 15 because the increase in the unit cost is not justified by the increased quality of instruction. We could substitute numbers in a formula and arrive at minimum, optimum, or maximum class size if we were only able to attach numerical values to the quality of instruction. We cannot, so we must ask our experienced academic administrators to use their best judgments to assign these limits in the light of current conditions.

In talking to faculty members whose primary interests are teaching and research, I have observed that few of them appreciate the problems of the academic administrator. With this in mind I should like to present their problem regarding class forecasting and offering.

The administrator must decide how many sections of each course should be offered. He uses class forecasting procedures to determine first approximately

how many students will take the course in the next school year. To add data to the Mechanisms course illustration, say this comes to 200 students. For a class limit of 20 at least 10 sections will be required. Because student programs and schedules vary, it is unlikely that each section can be registered to the limit and perhaps 12 sections will be offered. If the college is on the Quarter System, the 12 sections may be distributed into 4 offered in each of the three quarters. Enrollment patterns and staff and facility assignments are considered as the sections are designated and given time and room assignments. The total offering is published in a bulletin. From the catalogs and bulletins, students with the help of advisers plan a course of study for the coming terms.

Registration systems differ in many respects but suppose that each student in the College of Engineering requests a specific program of studies for Autumn Quarter. From published materials, he selects courses and designated sections and indicates the offering time he prefers on a schedule matrix to be assured that a non-conflicting schedule is possible. Each student submits his program with schedule to registration personnel. At that time he may be assigned to specific classes, but let us assume he leaves his request and is given an appointment for a later registration.

The requests of all of the students are tabulated. The administrator receives a report that 90 students have requested the Mechanism course with only 80 places available. Furthermore, the designated sections have enrollment requests of A = 35, B = 15, C = 24, and D = 16. The administrator notes that section A has requests of nearly twice the limit, C is slightly over, and B and D are slightly under-requested. Those with administrative responsibility have one or a combination of three alternative instructions to give registration personnel:

1. Assign students in the over-requested sections to vacant places in the under-requested sections. The remaining students who cannot take another section due to lack of capacity or conflicting schedules must select another course and *defer registration in this course to a later term.*

2. *An extra section of this course will be offered at the most useful meeting time.* Shift students in the over-requested sections into vacant places in the remaining sections.

3. *The class limit of 20 students is optimum in this case and the maximum limit is 28.* Try to rearrange student schedules to make enrollment in each section as even as possible but do not exceed the maximum for any class.

As a teacher or an administrator, one can readily appreciate the unsatisfactory consequences of each of these alternatives. Forcing the student to defer registration may be unsatisfactory particularly in sequence courses. It may be the only practical alternative in courses using limited and very expensive facilities. The alternative of adding sections may be difficult to accomplish. This involves shifting staff assignments or acquiring temporary staff. Over-enrollment in one class may leave under-enrollment in another thus allowing cancellation of one class to offer another. More classroom and laboratory facilities may not be available at the popular meeting times and a time assigned at an hour when facilities are available may be incompatible with the remaining class schedule of the students.

The third alternative of variable class limits seems to be the easiest solution from the viewpoint of registration mechanics. However, if limits are not cautiously controlled enlarged classes may affect the quality of teaching. It may also lead to inequities between staff members in the amount of teaching load, paper grading, and student consultation.

For each course the academic administrator attempts to select the alternative most practical at the time. When the majority of the classes are of the formal lecture type, the alternative of variation in class limits combined with some student schedule rearranging seems most satisfactory to the student and offers flexible administration around a rather

(*Continued on page 440*)

Rensselaer–Union College Conference on Electrical Engineering Education

A conference of some 20 professors from 14 different eastern educational institutions was held under the auspices of Rensselaer Polytechnic Institute on September 28 and 29.

The electrical engineering curriculum was the topic of consideration on the first day, held at R.P.I., with Professors W. A. Lewis, H. H. Woodson, L. V. Bewley, and P. D. Agarwal leading the discussion. While no precise agreements were reached, the following statement gives the consensus of the meeting:

Curriculum Content for the Junior and Senior Years

1) All electrical engineering students in the junior-senior years should be given a course in electro-mechanical energy conversion, with the purpose of giving the students an understanding of the nature, mode of operation, uses, and performance curves of usual devices, including telephone diaphragms, loud-speakers, contactors, transformers, rectifiers, and synchronous, induction, and d-c machines.

2) The course should not deal with the design of any of these devices, but should provide an understanding of the basic materials, the structural arrangements, and the functioning of the various elements of each device, so that the student will have a basis for the intelligent selection, appraisal, and application of usual electrical devices.

3) Preceding this course, all students should have a basic course in electric circuits and the principles of electromagnetism.

4) Also, preceding this course the student should have adequate mathematical preparation, including complex algebra, matrices, vector analysis, and calculus, including elementary differential equations and the use of the Laplace transform.

5) The energy conversion course should include:

a) Explanations of how to calculate the resistance, inductance, and capacitance of simple geometric forms, such as slot-embedded coils, parallel wires, and plates, and uniform air gaps.

b) Derivation of the forces between current-carrying circuits, magnetic fields, and electric charges. The force equations may be derived from Ampere's laws based on integration of the forces acting on each element of the circuit, or from differentiation of the total energy stored in the field. The force-element approach is useful for explanation, and for dealing with certain problems, but the stored energy approach is more widely useful and should be fully developed in the course.

c) Vector analysis and matrix methods should be used throughout, and a moderate amount of space may be devoted to explanation of these procedures as they are brought in, to reinforce the prior knowledge the students should have.

d) In general, the course should explain principles, and develop the properties of basic kinds of circuits. Particular machines or devices that are considered should be treated as examples of the general case, with full recognition of the effects of different choices for the design parameters.

e) Emphasis in the course should be placed on giving the student a sense of proper magnitudes, an ability to approximate, and the recognition of sound analogies, rather than giving

precise formulas or any details of design or application.

6) It is desirable that there be a considerable number of different books dealing with the above topics in different ways, and to different depths, so that each university may provide a course suited to its own teaching staff, student body, and fields of especial interest. Books that are considered especially useful at the present time are those by Adkins, Fitzgerald-Kingsley, Ku, White-Woodson, and those proposed by Bewley and by Lewis.

Graduate Study

The question of graduate study was also considered.

Here again no positive conclusions were reached, but the consensus of the group is indicated by the following statement:

In the United States, there are four widely followed procedures in graduate study.

A) The student takes up full time graduate study immediately following his under-graduate years, often at another institution.

B) The student takes up part-time teaching along with his graduate study immediately following his under-graduate years.

C) The student enters employment immediately following his under-graduate years, and later takes up part-time graduate study, either in the evenings or at stated periods alternating with regular work, under some cooperative plan.

D) The student enters employment for a few years and then takes up full-time graduate study for an extended period.

It was the consensus of the group that each of these methods has distinct values, and is the best for particular students. Under American conditions of early marriage and widely available assistantships, method B will be no doubt continue to be the most popular. However, the great need for more top-level engineers and scientists makes it highly desirable to extend the use of method D far more widely. Every effort should be made to encourage industrial and government support for this procedure of sending mature engineers to educational institutions for periods of full-time graduate study.

The meeting on the second day, held at Union College, was devoted to a discussion of laboratory experiments for electrical engineering students. This was led by Professors H. W. Bibber and W. R. LePage, and Mr. S. G. Ringland of the Technical Department of Mt. Pleasant High School, Schenectady, New York.

NEW PROGRAMS AT NORTHEASTERN

Northeastern University has established two engineering programs of study, one of which is the first of its kind in New England, and the other may be the first of its kind in the country.

Beginning next September, Northeastern will offer, for the first time in the six state area, an evening program of studies in engineering leading to the degree of bachelor of science in electrical engineering, according to an announcement by University Provost, Dr. William C. White.

In addition, the Graduate School will offer four master of science degree programs in engineering on the Co-operative Plan of Education. Northeastern will probably be the first university in the U. S. to give such a program of study on a graduate school basis.

Advising Engineering Students

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As a member of an engineering faculty you most likely have had, are having, or will have the opportunity to advise students in one way or another. To those of you who are presently "advising" students, an important question should be asked. How well do you *know* your "advisees"?

Are you one of the multitude of engineering faculty who is "so busy" that you only have time to sign the schedule card at the beginning of the term? Or are you one of the few who can call an advisee by his first name and discuss his home town and family situations with a certain degree of interest and familiarity? Most of us probably would have to admit that in reality we are for the most part "scheduling officers."

Engineering faculty are very busy with "extracurricular" activities such as committee responsibilities, some administrative duties, and research as well as preparing for and meeting classes. Even so, just stop and ask yourself the question: What is my primary purpose for being in the teaching profession? (Full-time research personnel are excluded because seldom do they do any advising at the undergraduate level.) The answer to this question, if you are not on full-time research, should be something like, "I like students and I'm interested in their technical development as well as seeing them mature intelligently and be a credit to the engineering profession." If there is any other answer, then we shouldn't be advising students.

In most cases the department head assigns faculty members to the job of advising undergraduate students. In too many cases this assignment is taken as an unpleasant chore with the attitude, "This has to be done and I'll take the easy way out." On the other hand, one who has answered the question of primary purpose will look on this assignment as an opportunity to help the undergraduate develop technical competence and attain the goals which will be a credit to the school and the engineering profession.

Because there are some differences in the handling of freshmen as compared to second year and upper class students, this paper will approach this advising from two aspects:

1. Freshman Counseling
2. Upper Class Advising

Freshman Counseling

It should be noted that in dealing with freshmen, the word "counseling" is used. Some will argue that advising and counseling are synonymous, but the author believes that there is a more personal contact with the idea of stronger guidance connoted by the word "counseling." This is exactly what is meant here. Freshmen need considerable guidance in all phases of their new life. Most schools of higher learning have special agencies to counsel freshmen on behavior, religious problems, study habits, and other matters. The primary concern of this writer is to discuss the "academic" counseling for which we have a large responsibility as a member of an engineering faculty.

Obviously, no counseling can be done without a great deal of knowledge about

This paper was written for the purpose of helping engineering faculty members advise their students better. Included here is a smattering of psychological fact combined with a "How-to-do-it" approach based on several years' experience of advising undergraduate students.

the person being counseled. Furthermore, the counselee must want to be helped. He has to be willing to "lay the facts on the table." He must be willing to confide in the counselor before anything can be accomplished. These are sound psychological facts. If you don't agree with these statements, think back to a time that you were given some unwanted "counseling." How did you react? How receptive were you to the unwanted advice, even though it turned out later to be quite sound? A new student cannot be expected to wholeheartedly accept our counseling unless we have made an honest effort to get to know him as a friend and he realizes that we *want* to help him. A mutual respect and confidence must be engendered between the advisor and the student.

How is this friendliness, respect, and confidence developed? In short, prove to the new student that you are sincerely interested in his welfare and want to help him. This is easier to say than do.

Let's back up for a moment and see how a new freshman is handled during the first few days of registration week. Usually these days are full of meetings and instructional periods prescheduled in large groups to the point that the new freshman feels that he is being herded like cattle from one place to another. Occasionally he finds that he must be in two places at the same time. For the most part there is nothing "personal" about any of them. Some freshmen who are away from home for the first time are very much "alone in the crowd."

Because most beginning freshman engineers take the same courses, it is common practice to have them prescheduled in their respective classes before they arrive on campus. Thus a freshman advisor can even schedule his advisees in a group situation. This is fine as far as efficient scheduling goes; and the author is very grateful for this work-saving scheme. However, the fact remains that we still don't get to know these freshmen in a personal sense.

One way that the writer has found very satisfactory in getting to know his advisees better is to schedule interviews with each one. As the signed schedule is handed to the student, the date and time for the interview is also given to him. The interviews are "scheduled" in the attitude of giving an assignment which must be completed. It has been found that if it is made in the form of an announcement which may be heeded if the person feels so inclined, very few freshmen even bother to come. Thus, the first "talk" is a command performance.

This first interview is nothing more than a chat where questions are asked about the advisee's home town, his parents, father's occupation, high school interests and activities. Naturally, he may also be asked about his work thus far in the term. If he is having trouble with any courses, try to determine what may be causing it. This is sometimes difficult because a new student is very reluctant to blame himself for insufficient preparations or other shortcomings just as we would be in a similar situation. By getting the student to discuss the kind of difficulty he is having and helping him to determine the reason for it, he will usually come up with some sort of a solution. Even though this "chat" should appear to the advisee as an informal talk, it should be planned to not only put the person at ease but also to secure some information which will help the advisor to become better acquainted and gain some insight for later interviews.

In addition to getting acquainted informally, these interviews should have three objectives: first, to help the students overcome "facultyphobia" and to get across to them that we want to help them with their problems; second, by the nondirective approach, to get them to talk about themselves in relation to their problems. A pertinent question or comment will help get them started; then let them talk. Never interrupt the conversation. It is quite surprising to see their reactions to this as they begin to see how they can help themselves. The third thing to be accomplished is to set the stage for their coming back. This has to be "played by ear" depending on the advisee. With some (if you have done a good job) you may casually mention that they drop in and see you any

time; you will always be glad to talk to them. With others you have to say "see me on —— day and let me know how you made out with ——." This latter technique must be continued with a few until they get the idea that they can see you any time it is convenient.

It is evident by now that we want the student to feel free to stop in and see his advisor at any time with any problems whatsoever. Sure, there may be some situations which are insignificant, irrelevant, and immaterial, but these are few and far between. Also remember that these situations are not insignificant to the new freshman. At any rate, if we expect him to come to us with a real problem, we have to cultivate his habit of coming with any problem.

Let's take the case of Jerry Holmes. Jerry was rather bashful and somewhat reluctant to talk to anyone about anything. During our first interview it came out in our conversation that he had gone into military service soon after high school. While in the service he was married. He is now coming to school on the G. I. Bill after being out of high school five years. He is living in a trailer with his wife and two children a few miles away from the campus.

A second talk with him came right after the mid-semester "below-grades" came out because he wasn't doing well in mathematics. As we talked we discussed what caused the poor mark. He stated that he had forgotten a lot of mathematics in the five years he had been away from school. He also stated that it was beginning to come easier since he was "learning how to study" more effectively. He did indicate that he would like some outside help with it, if it could be arranged. This was taken care of by contacting a friend in the mathematics department so that Jerry and the tutor could get together. I asked him to let me know how he was making out from time to time. He came in again three times during the remainder of the semester. (Incidentally, he passed *all* his courses that semester.)

The next semester he stopped in to see me three times about different things on his own accord. It wasn't necessary to send for him because of poor grades this time because he was doing well in all of his work.

Upper Class Advising

It is hoped that by the time a student reaches his sophomore year, he will have acquired the habit of consulting with his advisor whenever the need arises. In many cases which come up during this period of a student's career, the advisor assumes the role of a "walking directory." He can't be expected to have all the information at his finger tips or know the answers to all the problems about which the student desires answers. However, it should be the advisor's responsibility to know *where* the information may be secured. He should be able to direct the student to the proper person or place for the answer to the specific problem.

To take this out of general terms and get down to cases, check yourself on how you would handle the following situations:

1. How can an exceptional, grade "A" student get financial assistance?
2. How can a mediocre to poor student get financial assistance?
3. How does a student get credit for a course taken at another university during the summer?
4. Where may a student determine his reading ability and secure help to improve it?
5. What is the procedure to change curriculums within the college; within the university?
6. Where can a student get academic assistance (tutoring) in courses such as mathematics, chemistry, etc?
7. Where can a student find employment?
8. What are the regulations concerning an armed services veteran taking ROTC courses?
9. How does a student get excused from classes if there is a death or serious illness at home?
10. Where is the Lost and Found department?

These are just a few of the simpler ones which come to mind. The difficult problems are those dealing with academic regulations set forth by the university governing body and college faculties. Fortunately, here at Penn State our college has an Advisor's Manual which is kept up to date on new regulations and changes in former regulations of this type.

What about the student who gets into scholastic difficulty? How should an advisor handle this situation? (This applies to freshmen as well as upper classmen.) This must be handled in two parts because the advising is slightly different for "mid-term below grades" than for "term-end failures."

The mid-term below grade calls for a "command appearance." However, it has been the writer's experience to have the conscientious student come in for consultation without being summoned. As his advisor you should have a copy of his schedule of classes. By comparing his schedule with your schedule, a suitable meeting time for both of you can be determined. He can then be notified to appear at the appointed time either by telephone or a postcard. The author personnally feels that a telephone call by the advisor is the best approach. Perhaps this is beneath the dignity of a majority of the readers, who would rather push this task off on a secretary. "That is not my job" can be read in many of your minds. . Not only are the department secretaries overworked with their regular duties, but for the most part your advisees are merely names on a list to them. You are the student's advisor; he knows you. It would mean a lot more to him to get a call from you to come in for a consultation than to have a girl call and say "Mr. So-and-So wants to see you in his office at such-and-such a time." When the contact for a consultation is made by the advisor, he is carrying out the point of being just a little more personal.

When the student comes in to discuss the below-grade, give him a chance to talk and explain why and how it came about. This is the spot where knowing your advisee comes into real focus. It is at this point that excuses must be separated from legitimate reasons. Don't be too quick to jump to a conclusion. There may be several good reasons for a person to find himself in this situation. By good questioning and listening you can gather enough information about the below-grade to help get the student "back on the track" to successfully complete the course.

Knowing your advisee is important again in helping to find a way out of his dilemma. A few students need disciplinary treatment when all the evidence points to the fact that they have been lying down on the job. Others will react more favorably to a certain amount of sympathy (not overdone at all) and suggestions as to what they can do. To repeat a former statement a little differently, the important thing is to help the student analyze himself in light of his problem.

Be sure to follow up on the agreed-upon method of attack, particularly with the critical cases. Have the advisee see you in a couple of weeks and report on how he is making out. With some, a specific appointment must be made; with others the "let me know how you make out" will suffice. You should *know* your advisees well enough to decide which treatment is better.

The end-of-the-semester failures of your advisees present another problem. However, if you have been able to do a good job with the mid-term problems, these should be reduced considerably. All the good advising in the world will be to no avail in some cases. Lack of maturity, poor instructions, illness, personal problems, and the like will take their toll, and will result in some failures.

Perhaps at this point many readers are saying, "What is the problem? The student must repeat the failure and that is all there is to it." At the junior and senior level this is usually quite right. The student is (or should be) well along in a given curriculum and knows where he wants to go and what he has to do to get there. Sophomores on the other hand are just beginning to get courses in their chosen field. When these courses give them trouble, a doubt sometimes

arises in their minds, "Is this where I belong? Am I going to enjoy this kind of work, if I am having trouble with it now?" It behooves the advisor at this point to ask these questions to himself about a specific advisee who seems to be having trouble. Also take a look at his past record, particularly the technical courses. Adding all these things together with knowing him as you do, you can help him decide whether he should continue in his present curriculum or consider a change.

In addition to the usual case in which the advisor and the advisee can come to a mutual agreement on what should be done, the advisor also has two other problems at this time: first, to prevent from leaving the engineering curriculum the student who has the ability, but is scared that he will flunk completely out of college; second, to move out of the curriculum the poor student (from an engineering standpoint) who insists that he wants to stay.

When you are confronted with the first problem do all in your power to encourage the advisee to stick it out. If he really has the ability he is only running away from himself. It is the advisor's responsibility to help this person "grow up," realize his potential, and develop self-confidence. This is not an easy task, particularly when the student seems to have his mind set on leaving. The nondirective counseling approach is usually effective in cases such as this. As an advisor, try to put yourself in this student's place and realize how it would feel. When you have an appreciation of what makes a person act in this way, you have an idea of what to do to correct the situation. Sometimes, it is helpful to mention others who have been in a similar situation and who have gone on to be successful both in school and after graduation. Knowing your advisee will help you to help him recognize his potential. No matter what method or technique you use, it must be *his* decision to stay. In no manner must it appear that you are trying to pressure him into it.

In cases like the second problem, we never want the student to feel that he is being "kicked out." As an advisor we should try to help him find a curriculum which will suit his interests and abilities. In light of his past performance and your knowledge of him, suggest some curriculums which seem to fit his personality, interests, and potential. If your knowledge of a given curriculum isn't too deep, suggest that he talk to the head of that department. Sometimes, it is necessary to point out that if he continues in the present curriculum, he may be asked to leave if he continues to fail required courses. When this still doesn't convince him, suggest that he talk it over with his parents. Usually they receive a notice of any courses failed. When talking with his parents doesn't alter the case, suggest that he bring his parents in to see you. (Perhaps several readers at this point will object and say that an advisor shouldn't have to go this far. However, it is the writer's opinion that everything should be done to get the student "on the right track" toward a successful career. Having the parents come in is usually a last resort "switch" to route the student onto his right track.) When you have gone over the whole situation with the parents and still to no avail, let nature take its course. When the student doesn't make the grade and is asked to leave, don't say "I told you so." Indicate that you are sorry that things turned out as they did, and wish him luck wherever he goes.

Henry Carey's situation comes to mind at this point. Henry came from a farm background and was interested in agricultural engineering. The results of the usual examinations, which all Penn State Freshmen must take, indicated that he had a 15% chance to graduate from *any* curriculum. (Each advisor here at Penn State receives from our Division of Counseling a "Profile of Academic Abilities" for each student he advises. This profile sheet indicates the relative standing on each examination compared to both the Penn State population and the general population. It also predicts what grade point average the student would probably get if the normal amount of effort were put forth.) Henry's test scores were either in the "fair" or "poor" range right down the line. These are the two

lowest. His predicted average was 1.4 (a 2.00 average is necessary for graduation). This kind of a situation makes one ask, "How can this be when according to his high school record he was in the 2nd fifth of his graduating class." Being a State University we are supposed to admit within-the-state applicants in the 1st and 2nd fifths without special entrance examinations. (The case in point indicates the need for establishing better college entrance standards which will offset the quintile ranking of high school graduates. A 2nd fifth graduate in some schools would be a 5th in other schools.)

It was evident from the start that Henry was in for a tough time as a freshman engineering student. It was hoped that the prediction was wrong (occasionally they are) and he would be an exception to their prediction. They were wrong all right but not in the way implied in the foregoing statement. They just didn't predict *low* enough. At midterm Henry had below-grades in mathematics, chemistry, engineering problems, and a no-credit English course. The "handwriting on the wall" was quite clear to the advisor at this point.

During the "command performance" interview the advisor asked, "Have you ever considered teaching agricultural subjects in high school?" The hope was that Henry would realize that engineering was not for him and begin to think in terms of where he would fit better. He indicated that it hadn't entered his mind. It was suggested that he think about it and talk it over with his parents. He was reminded that before he could go to any other curriculum, he had to pass the present semester courses. When he was asked if he wanted some outside help, he refused it. He was asked to come back in two weeks.

During the next chat, when it was implied that he wasn't doing much better, a very serious discussion took place in which it was pointed out very frankly what would happen if he continued as he seemed headed. At the same time the idea of changing to agricultural education was expanded to show how he would be getting some of the same "ag" courses in that curriculum as he would in "ag. engineering" but without needing the math or basic engineering courses. Since this took place just ahead of Christmas vacation he was asked to talk it over with his parents and get their approval in writing to make the change. He was to come back after the holidays and take preliminary steps to make the change.

The advisor was quite surprised to learn that Henry's folks "thought he should stay where he was," with no written approval coming back to make any change. The whole picture was gone over again and Henry was told to bring his folks along when he came in to register for his 2nd semester. It was felt that perhaps they didn't understand the whole picture and the advisor wanted to make things clear.

At the end of the semester Henry's grade card showed failures of 12 out of 17 credits for a .80 average. There was no doubt in the advisor's mind what had to be done.

At registration time, Henry appeared with his father. Once again the whole story of what had happened and why, along with what would happen if he continued in the "ag engineering" curriculum. Also suggesting that "ag education" might be a place where Henry could find himself and continue on toward graduation. After all this, which took a good part of an hour, the father said, "Whatever Henry wants to do is all right with his mother and me." The advisor had a hard time containing himself at this point, but he managed to courteously bring the session to a close and help Henry prepare a schedule for the spring semester.

To bring this long story to a close quickly, Henry managed to pass the repeated courses but with only "C's and D's." He failed a two-credit drawing course and came out of his second semester with a 1.04 semester average. This brought his cumulative average for both semesters to a .92 and nature took its course; he was asked to leave Penn State.

This is only one extreme case, but it does point out that advisors can only go

so far. There are lots of other cases where suggested changes out of engineering were heeded and the students went on to do well in other curriculums. Also cases could be cited where "good" discouraged men were persuaded to stay and now are a credit to the engineering profession.

Advisor Loads

Some are probably wondering how many students one advisor can handle, using the methods described so far. Commenting from the personal experience of advising students for over ten years, it is the author's opinion that between twenty and twenty-five students can be handled satisfactorily. The fewer students a faculty member has to advise the easier it is to do a good job. If more than twenty-five are advised, some of the "personalness" is lost.

Another item of importance should be mentioned at this point. It has been found that carrying the same group of advisees all the way through their four years is much better than having a different group each year. This is particularly true from the student's standpoint. Some schools operate on the basis that freshmen are handled by certain faculty members, sophomores are handled by other faculty members, etc. It is obvious that a student can't develop a feeling of "knowing" his advisor when he is changed each year and vice-versa. This type of advising promotes the "scheduling officer" atmosphere.

Speaking of scheduling brings up the last item to be covered. How do you help your upper class advisee make out his schedule? Does he make it up and you sign it, or do you make suggestions as to courses, number of credits carried, and instructors? Needless to say a lot of students are looking for the "easy way out" and schedule their courses accordingly, with no Saturday classes, no eight o'clock classes or four o'clock classes. This can present some problems upon which you have to take a stand. Sometimes the time-table of class meetings comes to your rescue with certain times and certain instructors.

It is too bad that all instructors do not have the same standards of discipline, grading, and teaching, because the word gets around among the students as to "who" teaches "how." If there is a choice, most students will choose the "easier" teacher, even though more knowledge can sometimes be gained from the "harder" instructor. This is another place where your knowing your advisee will help you convince him that the harder instructor may be more benefit to him. (This should not imply that the writer feels that teaching always breaks down into these categories. It is realized that there are all shades of good to bad and easy to hard as well as combinations of these.) Actually this is a department problem and should not be discussed here except that it does come up when advising. The only suggestion about this from this author is, "Use your own good judgment."

To get back to this scheduling problem aside from instructors, it is felt that the advisor does have a lot of responsibility to help the student in his scheduling of courses. The engineering students here at Penn State do not have much choice of courses except in the case of a few electives. In connection with these choices or in connection with carrying an overload or underload, the advisor can fulfill his responsibility of advising by putting it on a "man-to-man" basis. By pointing out the pros and cons of a given situation tactfully and with discretion the advisor can allow the student to make his own choices. This becomes more important as the student moves closer to graduation because we want to develop in him the ability to make decisions and to live with them. Sometimes he chooses wrong, but if nothing too drastic comes of it, he has grown in the process.

All through this article, an attempt has been made to emphasize that advising must be a personal thing between the student and his advisor. This does not mean that he should coddle or pamper the student by doing everything for him. Rather, the advisee should be guided and directed only when necessary to help him mature into a respected member of

the engineering profession. In short, to paraphrase an oftquoted passage, treat your advisee in the same manner in which you would like your son (or daughter) to be treated if he (or she) were being advised by someone other than you.

(*Continued from page 373*)

► . . . . That the *Journal of Research of the National Bureau of Standards* is now divided into four sections, each being separately subscribed to? The four sections are Physics and Chemistry, Mathematics and Mathematical Physics, Engineering and Instrumentation, and Radio Propagation. Domestic annual subscription rates are $4.00, $2.25, $2.25, and $4.00, respectively. The change was made to meet the specialized needs of today's scientists and engineers, to improve coverage of the Bureau's technical program, and to improve cataloging and reference for the Bureau of Publications.

► . . . . That the Middle East Technical University is being established in Ankara, Turkey, to meet the rapidly developing technical needs of the Middle East. Students from all over the Middle East are to attend and it is believed that ultimately at least one-third of the students will be from outside of Turkey. At present 500 students are enrolled, but ultimately it is expected that there will be 20,000 students in the University and various Research Bureaus. The teaching staff is being recruited from all countries and all instruction is to be in English. An independent board of trustees has just been established. For all offices from President through the Deans, Directors, and Chairmen of Departments there is to be a balance of one Turkish member and a counterpart from another country. For the past year the Consultant President has been Dr. W. R. Woolrich, Dean Emeritus of the University of Texas and Past-President of ASEE.

► . . . . That a Survey of Registration Fees of engineering societies made by the Society of Exploration Geophysicists indicates that 60% of the respondents charge a registration fee which covers "admission" only? Tickets are then sold for special functions and services in order that they pay their own way. Twenty per cent have a single combined fee ranging from $5.00 to $50.00, and another 20%, which are essentially special cases, charge no fee. Twenty-seven of the 36 respondents who have a registration fee charge more than ASEE; 2 charge less to non-members than members, 11 charge more to non-members, and 14 charge the same.

► . . . . That the Annual Meeting is to be at Purdue University on June 20 to 24? You will want to plan on getting there a little earlier than usual because Monday is going to be a much more significant day than at any time in the past. Monday afternoon's General Session will be the real kick-off with a nationally known figure giving a major address, along with the President's address and welcome from Purdue's President F. L. Hovde who, incidentally, is an individual member of the Society. On Monday morning many of the Divisions are cooperating with TI in presenting the report on the National Survey of Technical Institute Education.

► . . . . That the date for the Annual Meeting at Purdue given on page 6 of "Dynamic Influence in Engineering Education" should be June 20–24? Please make corrections! A mistake was made, and all due apologies are extended.

W. Leighton Collins
Secretary

The Teaching of Modern Mathematics to Engineers

JULES P. RUSSELL

Professor of Mathematics
Polytechnic Institute of Brooklyn

For those of us who enjoy reading detective stories, a suitable sub-title of this paper would be: "The Case of the Misplaced Adjective." What we are concerned with here is a modern approach, or point of view, as well as subject matter, in the teaching of mathematics to engineers. However, the term "modern mathematics" has become an acceptable and concise description of this concept.

The Holy Roman Empire was neither holy, nor Roman, nor empire; at least no one doubts that modern mathematics *is* mathematics. However, there is no dearth of doubts as to just what the term modern mathematics should imply for the undergraduate curriculum. The community of mathematicians has been studying this problem for some six years now, principally via the Committee on the Undergraduate Program (CUP) of the Mathematical Association of America and the Commission on Mathematics of the College Entrance Examination Board. Both these groups have, in their current study, produced excellent results in the form of recommendations of changes and modifications in modernizing curricula, not only in the colleges, but also in the mathematical preparatory work on the secondary school level. Their specific recommendations will not be detailed here, but they are available in recent publications of these two groups.

Not the least important result of their work has been the stimulating discussions provoked by their study, and the "airing out," as it were, of the widely divergent views on the implementation of this modernization. Very few of their recommendations enjoy unanimous support. On the one hand, we have recommendations that set theory, certain topics in abstract algebra, topology, etc. be incorporated into the college (and to a lesser extent, the high school) curriculum. Yet there still persists the view held by some, and expressed succinctly by Professor Morris Kline: ". . . the pure mathematics which the modernists wish to present is pointless mathematics, a manipulation of meaningless symbols which can appeal only to an esoteric group. . . . After studying meaningless axioms and meaningless theorems, their (the students') natural conclusion will be that the whole business is meaningless." [1]

It is incumbent upon those of us concerned with the teaching of mathematics to engineers to extract from both those points of view a mathematics curriculum which would incorporate those features of both which seem best fitted to suit our purposes. The purpose of this paper is to describe and discuss one such "modern" engineering mathematics curriculum formulated along these lines. [It will not be the first time that those in engi-

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[1] M. Kline, "Critique of Modern Mathematics," *News in Engineering*, The Ohio State University, Vol. XXXI, No. 1, p. 23.

Professor Kline has recently been elected to the Board of Governors of the Mathematical Association of America for the three year term 1959–1961. Professor C. B. Allendoerfer, member of the Commission on Mathematics and a "modernist", has been elected President for 1959–1960. We look forward to continued "lively" discussion!

neering education accomplished a constructive change in the mathematics curricula. Twelve years ago, we noted the unification of analytic geometry, differential calculus and integral calculus gradually being accepted, the impetus of which was largely provided by engineering education.]

A "Modern" Curriculum

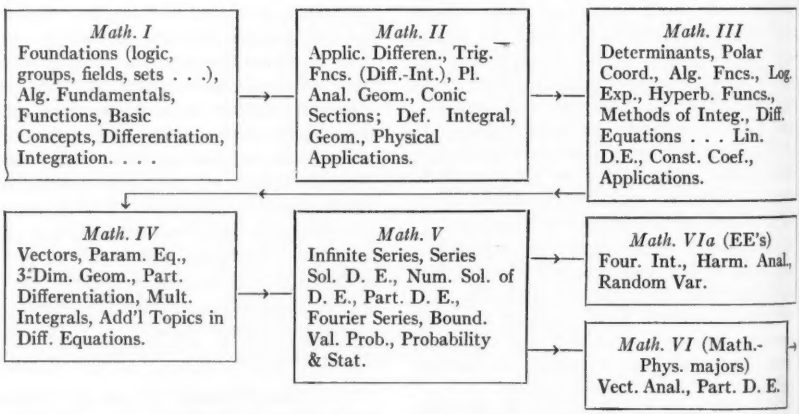
So let us proceed to consider a "modern" mathematics curriculum for all engineers. At the Polytechnic Institute of Brooklyn, where this program is now in effect, we have a five semester course, four credit hours per semester, aptly titled Mathematics I (for entering freshmen), II, III, IV, and V (for lower juniors), and required of all science and engineering majors.

Table 1 is a listing of the program, and it is to be noted that there are significant modifications both in content and in organization. Let us now discuss these changes in more detail.

The influence of the recommendations of the committees mentioned above may be seen in the first six weeks of the curriculum. The primary purpose of the incorporation of an introduction to logic is to familiarize the student with the basic concepts of the mathematical disciplines that will pervade all his future work. The meaning of such terms as necessary conditions, sufficient conditions, if and only if, negation, implication, logical arguments, and nature of mathematical proof, counter examples, the structure of a mathematical system, etc. are discussed in detail.

This is followed by a modern introduction to the concept of a function. The "ground rules" are established by defining such terms as domain, range, function, relation, graph, limits, continuity, and inverse of a function. Examples are then studied of the wide generalizations in the concept of a function, and how this framework is used by the engineer in a qualitative and quantitative study of a particular problem. The emphasis on the fundamentals of elementary functional analysis is accomplished by discussing, in addition to the more "usual"

TABLE 1


Math. I
Foundations (logic, groups, fields, sets . . .), Alg. Fundamentals, Functions, Basic Concepts, Differentiation, Integration. . . .
Math. II
Applic. Differen., Trig. Fncs. (Diff.-Int.), Pl. Anal. Geom., Conic Sections; Def. Integral, Geom., Physical Applications.
Math. III
Determinants, Polar Coord., Alg. Fncs., Log. Exp., Hyperb. Funcs., Methods of Integ., Diff. Equations . . . Lin. D.E., Const. Coef., Applications.
Math. IV
Vectors, Param. Eq., 3-Dim. Geom., Part. Differentiation, Mult. Integrals, Add'l Topics in Diff. Equations.
Math. V
Infinite Series, Series Sol. D. E., Num. Sol. of D. E., Part. D. E., Fourier Series, Bound. Val. Prob., Probability & Stat.
Math. VIa (EE's)
Four. Int., Harm. Anal., Random Var.
Math. VI (Math.-Phys. majors)
Vect. Anal., Part. D. E.

TEXTS USED IN MATHEMATICS I, II, III, IV, AND V

C. B. Allendoerfer and C. O. Oakley, *Principles of Mathematics*, McGraw-Hill Book Co., Inc., New York.

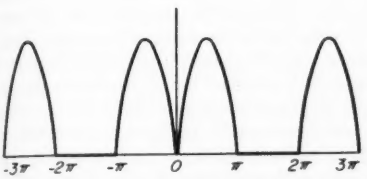
G. B. Thomas, *Calculus and Analytic Geometry*, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts.

M. Spiegel, *Applied Differential Equations*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

J. Kemeny, *et al.*, *Introduction to Finite Mathematics*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

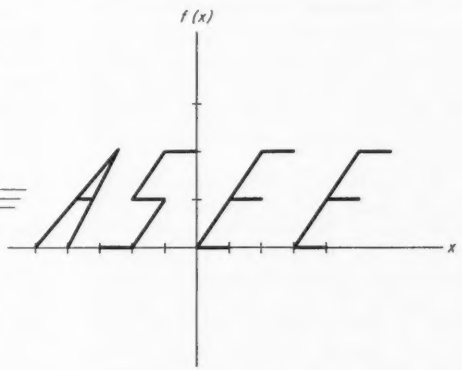
ones, functions which are not so common. The student may be asked to sketch the graph and discuss the continuity of the following function (he has already been introduced to the absolute value function and symbol, $|x|$):

$$f(x) = |\sin x| + \sin|x|$$
$$-3\pi \leqq x \leqq 3\pi$$



As another example, a typical assignment may be to sketch the graph, on the same set of axes, of the following set of functions listed in the left column (the student has been introduced to the "greatest integer" function and symbol $[x]$; he should not be too surprised that the graph of the set turns out as indicated):

$f(x)$	domain
$x + 5$	$-5 \leqq x \leqq -3$
1	$-4 \leqq x \leqq -7/2$
$2x + 8$	$-4 \leqq x \leqq -3$
$[x + 3]$	$-3 \leqq x \leqq 0$
$x + 2$	$-2 \leqq x \leqq -1$
$x + 3$	
$[x]$	$0 \leqq x \leqq 3$
x	$0 \leqq x \leqq 2$
$[x - 3]$	$3 \leqq x \leqq 6$
$x - 3$	$3 \leqq x \leqq 5$



The remainder of the first semester and the remaining semesters are devoted to the more standard topics, as indicated in the block diagram. Vector techniques are utilized exclusively in solid analytic geometry and in partial differentiation, making use of the scalar and vector products, the del operator, the gradient, directional derivative, etc. It should also be noted that numerical analysis techniques are introduced in the fifth semester in conjunction with the application of infinite series to the solution of differential equations. The last third of the fifth semester, some twenty hours, is devoted to an introduction to the mathematical theory of probability and statistics.

The order of presentation of the subject matter has been designed on the premise that the mathematical background of an engineer must serve both as a scientific discipline and as a vital tool. Therefore much stress is placed on fundamentals, the structure of mathematics, and the inherent continuity in the development of the student's mathematical background. The successful previous integration of calculus and analytic geometry is now carried one step further with the "desegregation" of differential equations. In addition to the immediate advantage of enabling the student to apply differential equations in conjunction with other physics and engineering courses, this also stresses the fundamental fact that mathematics has an inherent continuity, and should not be broken into compartments, as it were, by course catalogue descriptions.

Mathematics for a Foundation

Modern mathematics to engineers must also provide a firm basis for further study in upper level and graduate work in algebra, geometry, analysis and applied mathematics, both in the classroom and outside of the classroom. The modern

flavoring in the curriculum must reflect the fact that mathematics is a creation of the human mind, one phase of the general process of creativity to which the engineer is devoted, and, as such, new mathematics will continually appear. Substantial advances have been made in recent years in new applications of lesser known mathematical developments. Almost one hundred years passed between the time George Boole created his algebra of logic until Shannon, Hohn, *et al.* applied it to switching circuits. Today, the design problems of large and small scale computers, the development of so-called mathematical "brains," [2] automation, etc., have made Boolean algebra an engineering subject.

Modern mathematics in engineering education is rightly based on the premise that we should *educate* our engineers for the future, not merely *train* them as efficient appliers of today's methods and yesterday's theories. We can do this not by teaching only those mathematical "devices" that have been used in previous years. The modern approach in the curriculum seeks to equip the young engineer with the mathematical background that will enable him to understand, apply, and contribute to, the advances that have been made, and are to be made, in the "mathematical . . . sciences . . . applied with judgment to develop ways to utilize, economically, the material and forces of nature for the progressive well-being of mankind."

[2] A much more appropriate name, suggested by Professor M. Salvadori, would be mathematical "idiots." After all that's what they are!

(*Continued from page 426*)

rigid budget. Faculty members must then look upon class size *as an average* with reasonable variation expected and be prepared to adapt their teaching methods to larger and smaller enrollments.

Because faculty salaries account for the largest single cost of instruction, every effort should be made to increase the average size of classes. Conscientious teachers are continually trying to improve the quality of their teaching. *Should some of this increased productivity be directed toward teaching larger classes with lower unit costs of instruction?* Each of us as teacher, administrator, citizen or taxpayer has the responsibility of giving some new thought to this subject.

In summary, when we are making efforts toward more effective utilization of staff and facilities we can:

1. Review the instructional limits assigned to each class to make them variable with optimum and maximum numbers and make them larger where improved techniques or changed class format will permit.

2. Review and improve class forecasting techniques.

3. Review present registration procedures and controls.

4. Review class offering times and schedule patterns in an effort to increase the frequency of use of present facilities and to better plan new ones.

5. Conduct planned research in increasing the productivity of the engineering teacher. This will involve both our curricula and our teaching techniques.

The engineer has been the leader in increasing the productivity of man in almost every other walk of life. Let's not overlook our own activities.

A Mathematician in an Engineering School

WALTER GEORGE WARNOCK

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It became the custom early in the history of the Mathematics Division, and indeed it is now so stated in our by-laws, that the retiring Chairman say a few words at some point during the Annual Meetings. Many of these discussions have made significant suggestions for improvement of the curricula and of teaching techniques. Of course it does not happen that each retiring chairman's talk points to far-reaching results, and rightly so, else we would be in a continued state of confusion. I shall attempt to avoid creating a state of confusion, so let us relax and talk about ourselves and each of us think of himself as a mathematician in an engineering school.

Of course, as is often the case, conversations have much more spark when we include our neighbors as part of the topic of discussion. In this instance our neighbors are to be our friends teaching engineering subjects in those buildings across the way. And who are they? And how well do we know them? Do they know us? Do we understand each other?

We must always keep in mind that these engineering friends and educators may have different ideas as to how their students should be trained, or educated if you prefer. We have heard engineers say that they are development men. They make things and make things do other things and this goes on in an ever-changing economy. Naturally then, they insist that their students learn how to make things do other things in an increasingly complex society if these students hope to become successful engineers. Of course this is an oversimplification of the facts, and it is a gross understatement to say that engineers are merely development men.

It is a fact that our engineering friends have a natural tendency to think in terms of materials instead of symbols, and because symbols may be somewhat more abstract and therefore more difficult to use, we should put forth some effort to talk in terms of their language. Likewise, we should bear with that particular engineering neighbor who insists upon solving all differential equations he encounters by use of infinite series and who argues that all of the students in his sections do likewise. Perhaps a mathematician was unusually enthusiastic one particular day of the past when infinite series were the topic of the day and it caught this individual who is now our engineering professor. Or it may be that the enthusiasm is for some other technique and that the insistence is again for all students of that department to be exposed for an unnecessarily long period to that favored topic. It behooves us to try to talk correctly in the language of our neighbors, as it does to help them use our language correctly.

However, it seems to me that as a college the engineers have been doing a remarkably good job for their students in the mathematical area. We should recall that some of their departments, electrical engineering for example, have required a first course in differential equations for twenty or more years, and that it is the exceptional degree department that does not insist upon at least one term of mathematics beyond the calculus. Indeed it may have become the very exceptional

Presented at the 67th Annual Meeting of ASEE, June, 1959, Pittsburgh. Recommended by the Mathematics Division.

department that does not encourage its students to take an extra course in mathematics when the opportunity in their schedule arises.

The Increased Demand

You may have read the recent report in the JOURNAL OF ENGINEERING EDUCATION by L. E. Grinter entitled "A Survey of Current Changes that are Modernizing Engineering Education" (JOURNAL, Vol. 49, No. 7, March, 1959, pp. 559–572). If so, you will have noticed that the demand for mathematics in engineering curricula is accelerating. This demand comes from the engineers themselves and there seems to be little doubt that within the next five to ten years it will be the exceptional degree program that does not require three full years of mathematics. It might be advisable for us as mathematicians in an engineering school to be setting our sights even now for that time when four full years of mathematics are required of us. There are few areas of educational endeavor that insist upon more from the departments of mathematics than do the engineers, and I feel we should keep this in mind and appreciate the fact.

I believe we have talked enough about our neighbors for one sitting, so let us return home. It is rather trite to mention that we have more students in our sections these days and that these larger sections continue through the more advanced courses. What were once the optimum requirements have long since become the minimum. But there is more to the change than that more students are reaching the same goal. An acceleration and a careful selection of subject matter are taking place, so that today many colleges schedule differential equations rather than the calculus for the regular second term sophomore course.

This year, for instance, if you will pardon local references, we at Rensselaer introduced high speed digital computer techniques in this second term of sophomore differential equations. On the basis of this trial run with five or six sections, the Director of our computer laboratory believes he can plan techniques and section schedules so that in the future each student taking differential equations will have the experience of programming and checking at least one problem of his own through a digital computer.

Of course many engineering schools have not been able as yet to reach the differential equation course so early in their program; many difficulties still complicate this goal. That this is a desired goal should not be lost sight of. Engineers and science students must be able to use mathematical tools and they must understand their use early in their educational career if scientific technology is to keep pace with research information. For the engineer the immediate need will continue to be that branch of mathematics known as analysis. Other branches of mathematics are gradually becoming necessary in an engineering career, but I feel that a delay in their study is less critical than a delay in analysis.

Obviously a large part of our difficulties could be eliminated if our high schools took over most of the elementary mathematical training, particularly if the high schools would set their sights to include the calculus as part of their fourth year mathematics. I do not mean just an intuitive sketch of calculus; I do mean a serious beginning of college calculus so that we could take up where they left off. We all know that the exceptionally gifted student is able to accelerate his mathematical program by passing tests of advanced standing, but there are students of average ability who have been fortunate enough to come under certain outstanding high school programs and who have likewise been successful in respectably accelerated programs. The significant fact here is not that these students have been successful but that high schools can be successful in the teaching of calculus. However, I do not wish to suggest what high schools should do. I merely offer a statement of fact and I urge that we do not overlook the great possibilities in studies similar to the report by the Commission on Mathematics of the College Entrance Examination Board.

A Continued Program

This leads us right up to the question of what to do about a continued mathematics program for engineers. What kind of a mathematics program will make educational sense for upper division engineering students? The more able engineering student has always been coming to the mathematics department on his own seeking extra courses, and, as a rule, he has been directed to the traditional departmental courses of his level. But because he was on his own he had to work these courses into a full schedule as best he could and often this led to a haphazard program and prevented him from following a desirable mathematics sequence. It was practically impossible for him to take a "year" course.

It will be necessary for us now as mathematicians in an engineering school to concern ourselves with the formal requests of our engineering friends for their junior and senior year students and to put much thought and effort on their official degree curricula insofar as the mathematics is concerned. This puts a different complexion on the whole problem. It has enlarged from that of advising a few of the brighter students, or at most a section or so in some degree option, to one of presenting an extension of mathematics to many sections and several departments, with the downright knowledge that this program soon will be for all students of the engineering school.

We as mathematicians in an engineering school have not been entirely unaware of the problem as is witnessed by the textbooks recently written for engineering students of advanced standing. I do believe that the total impact has arrived sooner than we expected, and whereas we had hoped to be able to think about solutions to these new situations during the next five years, we *must* do so next year; this year even!

As mathematicians we have an immediate answer, and an appropriate one: let the students pursue the program of our mathematics majors. This would give them the necessary foundation in mathematics to follow through in any direction of engineering endeavor. But for mathematicians in an engineering school the solution to the problem is not so simple. These students are not our students; their interests are different and hence their motivations must be different. The majority of them are interested in mathematics only to the extent that the subject matter can help them in their chosen field. The engineering departments have *their* ideas also, as to what should appear in these new courses. We must accept the premise that these departments have as their first concern the best educational program for their students, and this does not exclude the best immediate professional training from being an influential factor of the total educational program. Consequently one major demand that will be placed upon an added mathematics course for all engineering students will be its immediate usefulness as a vehicle for extending the professional education of such students. Of course other difficulties will arise, but because the problem of crowded student schedules will still be present, the factor just mentioned is certain to play a dominant role during all negotiations between the departments of engineering and the department of mathematics. As mathematicians in an engineering school we are obligated to recognize such demands and to consider them with care; likewise, we are obligated to point out weaknesses that may appear in particular plans presented with the hope that working together, we can produce a better and more able engineering student.

The Package Program

At the beginning I remarked that I did not propose to offer any solution to any problem. I suggested that we talk about our neighbors and ourselves. I would like to make one observation only. One pattern of the extension of mathematics to the upper years seems to be in the making. I like to call it the "package" program and it is this: broad but immediately important mathematics topics for engineers are being organized into concise and self-contained chapters. There is no reason why these topics could not appear in small individual book

form. There could be much merit in this way of offering material to junior and senior students. We as mathematicians could make a selection of six to eight such packages and list them under one appropriate title as mathematics for junior engineers. The various engineering departments would indicate individually reasonable combinations of, at most, three such self-contained topics per term for us to teach to their junior or senior students. I mention three topics, for experience indicates that that is the most we can teach with success. It is at this place in the student's program that his advisors can recommend the topics in discrete mathematics that were neglected in the earlier years, and because of a certain increase in mathematical maturity it should be possible to make greater advances in the new subject matter during the same amount of scheduled time.

I have mentioned the term "oversimplification" on occasion and I have oversimplified our difficulties to the extreme. To bring this point home let me relay to you a question posed to me by one of our incoming freshmen who paid us a visit during Parents' Weekend a short while ago. The question was this: Will we be able to *continue* the study of set theory in freshman mathematics next fall?

Teaching Positions Available

ASSOCIATE PROFESSOR TO TEACH Kinematics, Descriptive Geometry and Engineering Drawing. Mechanics background and Master's Degree preferred. Write Wm. H. Francis, Head Professor, Engineering Graphics, Auburn University, Auburn, Alabama.

CHAIRMANSHIP IN CIVIL ENGINeering. Graduate and undergraduate teaching and research opportunities. Must have doctor's degree. Write Walter J. Seeley, Dean, College of Engineering, Duke University, Durham, North Carolina.

TEACHING IN PUERTO RICO. PH.D. teaching positions open. English or Spanish speaking. Opportunities in expanding civil, electrical, mechanical, chemical, industrial, and general engineering departments. Research interest imperative. Rank and salary will depend on qualifications. Write to: Dean of Engineering, University of Puerto Rico, Mayaguez, Puerto Rico.

OPPORTUNITY FOR MAN SEEKING promotion to head Mechanical Engineering Department. Master's degree required. Doctorate desirable. Location Eastern seaboard. Write to Brother A. Leo, F.S.C., Manhattan College, New York 71, N. Y.

SUBSTANTIALLY INCREASED FAcilities in the Department of Mechanical Engineering make it possible to offer two teaching positions in the subject fields of machine design, elasticity, mechanics and industrial engineering. Salary and rank appropriate to academic qualifications. Positions now open. Write to Dr. E. T. Ted Kirkpatrick, Chairman, Department of Mechanical Engineering, University of Toledo, Toledo 6, Ohio.

ELECTRICAL ENGINEERING. PROfessor or Associate Professor. Ph.D. required. Background in solid state, electronic devices, or electromagnetics preferred. Exceptional opportunity for right man. Apply Dean of Engineering, University of Toledo, Toledo 6, Ohio.

MECHANICAL ENGINEERING teaching positions. Men needed in the fluids-heat transfer-thermodynamics-aerodynamics area, in the theoretical and applied mechanics area, and in nuclear engineering. Large and rapidly growing graduate program through D.Sc. Sponsored research encouraged. No limitations on rank. Salary and rank commensurate with educational background and experience. Apply: C. T. Grace, Mechanical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

ELECTRICAL AND MECHANICAL staff openings at assistant, associate and full professor levels to teach in liberal arts college with new Engineering Science program. M.S. or Ph.D. required, industrial experience desirable. Write to S. Goldstein, Chairman of Engineering, Hofstra College, Hempstead, Long Island, New York.

EXCELLENT OPPORTUNITIES available at San Jose State College in fields listed below. Located in San Francisco Bay Area, center of expanding research, development and manufacturing activities. Newly accredited curricula and new M.S. programs. Ph.D. completed or in progress and teaching and industrial experience desirable. Contact N. O. Gunderson, Head, Division of Engineering or appropriate department head: Civil, W. W. Lorell; Electrical, J. T. Smith; Mechanical, S. B. Walton; Metallurgical, J. H. Anderson.

ASSISTANT OR ASSOCIATE PROfessor in Electrical Engineering. M.S. required. Ph.D. desirable. Interest in undergraduate teaching of primary importance. Apply to Head, Department of Electrical Engineering, Virginia Military Institute, Lexington, Virginia.

ASSISTANT PROFESSORSHIP IN ENgineering Mechanics and/or Structural Mechanics for rapidly expanding undergraduate and graduate programs. Salary dependent upon qualifications. Ph.D. degree in Mechanics or Structural Mechanics highly desirable. Write to Prof. M. P. Capp, Chairman, Division of Engineering, San Diego State College, San Diego 15, Calif.

CIVIL ENGINEERING-STRUCTURES. Opportunity to head structural division, teaching and directing undergraduate and graduate programs. Attractive possibilities in an expanding graduate and research program. Top salary and rank appropriate to qualifications. Ph.D. preferred. Positions now open. Write to L. M. Laushey, Head, Civil Engineering, University of Cincinnati, Cincinnati 21, Ohio.

CIVIL ENGINEERING APPOINTment: McMaster University. The Department of Civil Engineering and Engineering Mechanics solicits applications for a staff position in a new school with a stimulating research environment. The candidate should possess a graduate degree (preferably the doctorate) based on specialization in structures, and some experience in lecturing and research direction. Duties will include undergraduate and graduate instruction, and good research facilities are available. Appointment will be made at the rank of assistant or associate professor, depending upon qualifications and experience. Enquiries and the names of three references should be addressed to: Dr. J. W. Hodgins, Dean of Engineering, McMaster University, Hamilton, Ontario, Canada.

OPPORTUNITIES AT ROBERT COLlege, in Istanbul, Turkey, for qualified men in civil engineering or mathematics, interested in combining teaching and the development of limited research and consulting activities with the opportunity to live and travel in a vital part of the world. Strengthening staff, modernizing undergraduate engineering curricula, beginning graduate programs in engineering, developing undergraduate and later graduate programs in sciences, constructing new science and engineering building to prepare engineers for the industrial and technological development of Turkey and the Middle East. A challenging job with far-reaching possibilities. Address inquiries to Dean Howard P. Hall of the School of Engineering or Professor Frank Potts, Acting Dean of the School of Sciences, Robert College, Bebek, Post Box 8, Istanbul, Turkey; with copy to the Near East College Association, 40 Worth Street, Room 521, New York 13, New York.

ADDITIONS TO MECHANICAL ENgineering Staff at all professorial ranks. Attractive possibilities in an expanding graduate, undergraduate, and research program. Write to Donald M. Vestal, Jr., Head Professor, Mechanical Engineering, Auburn University, Auburn, Alabama.

HEAD, DEPARTMENT OF MOTORS; also head, Department of Mechanics; at U. S.-type engineering school. Teaching and research. Contract with liberal salary, income tax free. Travel paid; house provided, partly furnished; electric kitchen. Ideal climate. Write air mail to President S. S. Steinberg, ITA, São José dos Campos, São Paulo, Brazil.

ELECTRICAL ENGINEERING, ASSOciate or Professor, M.S. or Ph.D. degree required. Opening in electronics or power systems. Salary commensurate with experience, possibly $8,500. Position available now or September 1960. Write to: M. L. Manning, Dean, Division of Engineering, South Dakota State College, Brookings, South Dakota.

STAFF OPENINGS IN CHEMICAL, Civil, Electrical, and Mechanical Engineering at Ph.D. and M.S. levels. Excellent opportunities to work in an expanding graduate program. Salary and rank will depend on qualifications. Address: Dean of Engineering, New Mexico State University, University Park (Las Cruces), New Mexico.

ASSISTANT PROFESSOR TO TEACH Fuels and Lubricants and to be responsible for the laboratories in this course. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

STAFF OPENINGS FOR SEPT., 1960, in Electrical Engineering Department. Mostly undergraduate instruction. Attractive salary, living conditions. Recreation center of the West. Correspondence invited. I. J. Sandorf, Chairman, Department of Electrical Engineering, University of Nevada, Reno, Nevada.

POSITIONS AVAILABLE FOR teachers of Electrical and Mechanical Engineering, and for teachers of Mathematics. M.S. degree is the minimum requirement; the Ph.D. is desirable. Salary and rank will depend upon qualifications. Excellent fringe benefits. Apply to: Earle M. Morecock, Chairman, Division of Applied Science, Rochester Institute of Technology, Rochester 8, New York.

ASSISTANT PROFESSOR TO TEACH courses in Applied Mechanics and Dynamics. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

THE NEW COLLEGE OF ENGIneering of The University of Rochester is seeking additional staff in chemical, electrical and mechanical engineering to do teaching and research. Interested applicants should write to the appropriate department chairman at The University of Rochester, River Campus Station, Rochester 20, New York.

ASEE-AEC Summer Institute for Technical Institute Teachers

HAROLD BAILEY

Chairman

DONALD WHITWER

Instructor

Department of Mathematics and Science, Oregon Technical Institute *

Since job prospects for technicians seem more and more to include nuclear science and electronics, curriculums in technical institutes must reflect the influence of nuclear energy on education. Instructors, too, must keep abreast of latest developments and the second Summer Institute on Nuclear Energy for Technical Institute Instructors gave the participants ample opportunity to obtain the newest information in the field. They gained a good idea of the problems of nuclear energy and the background necessary for developing a realistic program for technicians.

The eight-week program, held from June 28 to Aug. 21, 1959, was sponsored jointly by ASEE and the Atomic Energy Commission. The first six weeks of the program were conducted at The Pennsylvania State University and the last two weeks at the Argonne National Laboratory in Lemont, Ill. The 22 instructors who participated represented 13 institutions in 10 different states.

The various speakers on the program defined the standards desired of technicians and the academic subjects needed to meet these standards. They further indicated that certain basic requirements are common to both industry and research. These requirements are:

1. A working and applied knowledge of mathematics through college algebra,
2. A working and applied knowledge of modern college physics and chemistry,
3. A fundamental knowledge of electronics and circuit analysis,
4. A knowledge of, and the ability to work with, hand tools.

The technicians in nuclear research would need more diversified talents and more capacity for independent thinking than would the technician in a comparable industrial nuclear field.

Technical institute instructors who qualify for the next ASEE–AEC Summer Institute on Nuclear Energy might well consider how recent has been their exposure to modern physics, chemistry, calculus, and electronics. The course presented this year was comprehensive, and a person deficient in these subjects would find it very difficult. He would need to "burn the midnight oil" with regularity to overcome this obstacle.

* Messrs. Bailey and Whitwer were participants in the second Summer Institute on Nuclear Energy for Technical Institute Instructors.

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Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 22–23, 1960	H. D. Sims, Bucknell University
Illinois-Indiana	Rose Polytechnic Inst.	May 14, 1960	E. A. MacLean, Rose Polytechnic Inst.
Kansas-Nebraska	Univ. of Wichita	Oct., 1960	H. L. Kipp, Univ. of Kansas
Michigan	Univ. of Michigan	April 23, 1960	R. Schneidewind, Univ. of Michigan
Middle Atlantic	E. I. Du Pont de Nemours, Wilmington, Del.	May 14, 1960	J. I. Clower, Univ. of Delaware
Missouri-Arkansas	Univ. of Missouri	April 23, 1960	Jos. C. Hogan, University of Missouri
National Capital Area		Oct., 1960	M. A. Mason, George Washington Univ.
New England		Oct., 1960	E. F. Littleton, Tufts Univ.
North Midwest	Marquette Univ.	Oct., 1960	R. J. Kipp, Marquette Univ.
Ohio	Fenn College Cleveland, Ohio	April 29–30, 1960	N. R. Rimboi, Fenn College
Pacific Northwest	Univ. of Idaho	May 13–14, 1960	Paul Mann, Univ. of Idaho
Pacific Southwest	Los Angeles State College	Dec. 28–29, 1959	Homer H. Grant, Univ. of Southern California
Rocky Mountain	USAF Academy	Apr. 29–30, 1960	Archie Higdon, U. S. Air Force Academy
Southeastern	Univ. of South Carolina	April 21–22, 1960	Jesse Coates, La. State Univ.
Southwest	Lamar State College, Beaumont, Tex.	Apr. 29–30, 1960	Frank Bromilow, New Mexico State Univ.
Upper N. Y.-Ontario	Univ. of Buffalo	Oct., 1960	C. M. Fozel, Univ. of Buffalo

Mid-Winter Meetings–1960

Cooperative Education — Feb. 11–12 — Georgia Institute of Technology
Information: J. G. Wohlford, Director of Cooperative Courses, Georgia Institute of Technology, Atlanta, Ga.

Engineering Graphics — Jan. 20–22 — Missouri School of Mines
Information: C. L. Wilson, Dean of Engineering, Missouri School of Mines, Rolla, Mo.

College-Industry Conference — Jan. 27–28 — Washington University
Information: D. A. Fischer, Dean of Engineering, Washington University, St. Louis, Mo.